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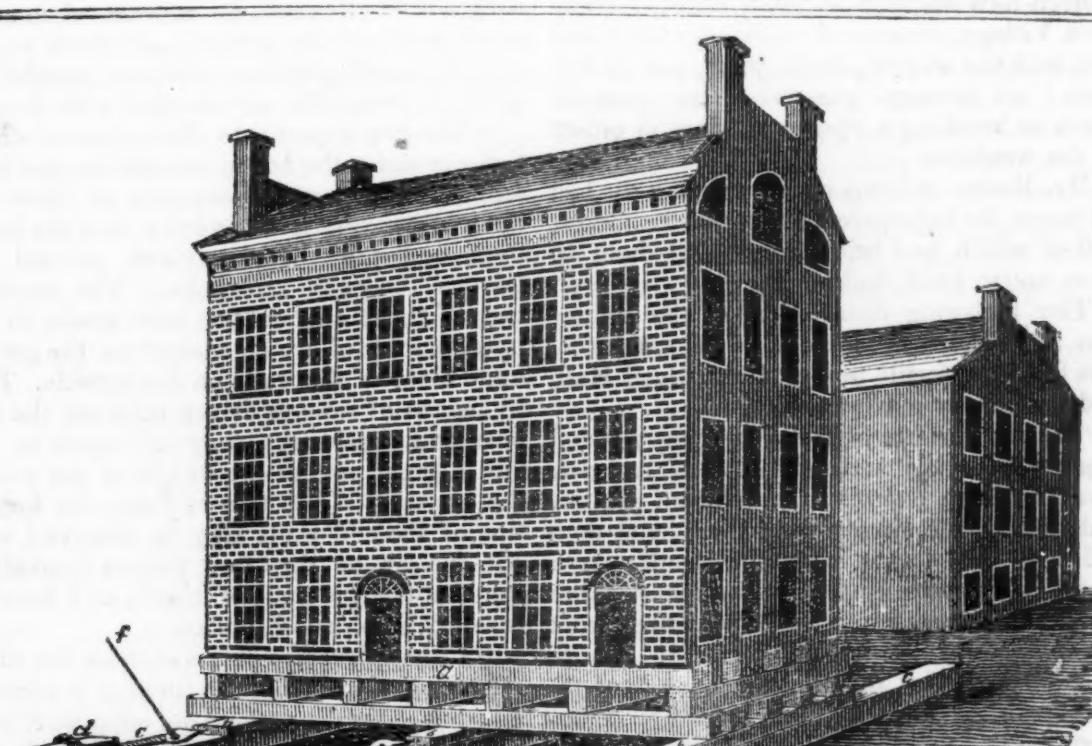
"*Knowledge* dwells
In heads replete with thoughts of other men;
Wisdom, in minds attentive to their own.
Knowledge, a rude unprofitable mass,
The mere materials on which Wisdom builds,
'Till smooth'd, and squared, and fitted to its place.
Does but encumber whom it seems t' enrich.
Knowledge is proud, that he has learn'd so much—
Wisdom is humble, that he knows no more."—COWPER.



Mr. Simeon Brown's Method of moving Brick Buildings. [Communicated by the Inventor for the Mechanics' Magazine.]

REFERENCES—*a a*, timbers placed in different directions, according to the construction of the building, so that it may be perfectly secure; *b b b*, the slides; *c c c*, the ways, on which the slides move; *d d d*, the pumps, (so named,) secured by chains to the ways, *c c c*, and containing the female screws, which are each provided with a shoulder, pressing against the end of the pump; *e e e*, the propelling screws, which are severally acted upon by a lever, *f*.

MR. SIMEON BROWN, Eastern Hall, Manhattan Island, has, by the simple apparatus as shown in the engraving, removed several

brick nouses, varying from one to three stories high. As we know that many people are quite incredulous on this subject, we subjoin a list of some few tenements that have been moved by Mr. B. in this city.

The first *brick* house Mr. Brown moved was situated at 85 Maiden lane; it is three stories high, and the size is 55 feet by 22. A short time afterwards he lowered Richmond Hill Theatre, a brick building, the wall 8 inches thick, size 50 feet by 42, and moved it a distance of 68 feet. Shortly afterwards seven brick houses, at one time and by one set of apparatus, in Monroe street, each 24 feet by 40; the numbers of the houses are 118, 120, 122, 124, 126, 128, and 130. Then nine brick houses, 25 feet by 40, situated in Avenue D, all raised 5 feet 2 inches, by one operation; and a three story brick house, 58 feet by 25, in Monroe street. The Church now situated in Sixth street, Greenwich Village, he moved a distance of 1,100 feet, with the steeple, clock, pews, and all fixtures; no damage was done, not even so much as breaking a square of glass in either of the windows.

Mr. Brown informs us that, during the last 12 years, he has moved about 900 buildings, 400 of which had brick fronts, and about 40 were entire brick buildings.

The following description of the operation Mr. Brown has handed us for insertion: it is from the fertile pen of Capt. Basil Hall, and is in every particular correct.

"Every one has heard of moving wooden houses; but the transportation of a brick dwelling is an exploit of a different nature. I shall describe simply what I saw, and then tell how the details were managed. In a street which required to be widened, there stood two houses much in the way, their front being twelve feet too far forward. These houses, therefore, must either have been taken down, or shifted back. Mr. Brown undertook to execute the less destructive process. They were both of brick, and built together, one being forty feet deep, and twenty-five feet front; the other thirty-two feet deep, and twenty-two feet front. They were of the same height, that is to say, twenty-two feet from the ground to the eaves, above which stood the roof and two large stacks of brick chimneys; the whole formed a solid block of building, having two rows of six windows each, along a front of forty-seven feet by twenty-two. This was actually moved in a compact body, without injury, twelve feet back from the street. I watched the progress of the preparations on the 25th of May with great interest; but unfortunately, just as the men were proceeding to the actual business of moving the screws, I was obliged to run off to keep an appointment with the Mayor and Corporation; and when I came back, three or four hours afterwards, the workmen had gone away, after moving the building thirty inches—which fact I ascertained by measurements of my own. On the next day, with equal perversity of fate, I was again called off to join a party going to New-Jersey; and on my return two days afterwards, I had the mortification to find the work completed. The houses were now exactly nine feet and a half from the position in which I had left them a few days before.

"It would be tedious, perhaps, were I to give a very minute description of the whole process; but it is so simple, that it may, with a little attention, be understood in a general way even by persons not much accustomed to such subjects, and may possibly be useful to those who are familiar with them.

"The first object is to place a set of strong timbers under the house, parallel to, and level with the street, at the distance of three feet apart, extending from end to end of the buildings, and projecting outwards several feet beyond the gable end walls. The extremities of these timbers are next made to rest upon blocks of wood, placed on the ground quite clear of the walls on the outside. Then by means of wedges driven between the timbers and the blocks, they are made to sustain a great part of the weight of the ends of the house. When this is done, the foundation of the end walls may be removed without danger, as they now rest exclusively on the timbers, the ends of which, as I have described, lie on solid blocks.

"I shall describe presently how the above operation of inserting the timbers is performed; but if for the present we suppose it done, and the house resting on a sort of frame-work, it is easy to conceive that a set of slides, or what are called in dock-yards, ways, on which ships are launched, may be placed transversely under these timbers, that is, at right angles to them, so as to occupy the very place where the foundations of the end walls once stood. It is necessary to interpose between these ways or fixed slides, and the aforesaid timbers, a set of cradles, similar in their purpose to the apparatus of the same name on which ships rest when launched, to which final process of ship-building, by-the-bye, this whole operation bears a close analogy.

These cradles are long smooth beams lying along the top of the ways, and in the same line with them; their under surfaces in contact with the ways, and the upper made to bear against the cross timbers which support the house. The object, at this stage of the business, is to bring the whole weight of the house upon these cradles, and, consequently, upon the ways which support them. If this be done, it follows that the ends of the timbers, formerly described as resting on the blocks, will no longer be supported at the same places. This change of the point of support is effected by driving in wedges between the timbers and the cradles; and it will readily be seen that these wedges have the two-fold effect of forcing the cradles down upon the ways, and at the same time of raising up the timbers which support the house, and consequently, in a very small degree, the house itself. The ends of the timbers now rest no longer on the blocks, which are removed, and the house, supported upon the cradles and the ways, is ready for being moved, as soon as the front and back walls have been taken away.

"Suppose all this done, there is nothing required but to apply screws, placed horizontally in the street, and butting against the cradles. On these being made to act simultaneously, the cradles, and consequently the frame which they support, together with the house on its back, move along.

"Such is a general account of the process. I shall now mention how the various difficulties, most of which I dare say will have suggested themselves in the foregoing account, are overcome in practice.

"The horizontal supporting timbers, already described as being placed parallel to the street, and nearly at the same level with it, are introduced one by one in this way. A hole is blocked out in each of the end walls, just above the ground, and large enough to admit a squared beam, say fifteen inches each way, of which the ends project beyond the gable walls about a couple of feet. A firm block of wood is then placed under each of these ends, and wedges being driven underneath, the beam is raised up, and made to bear against the upper parts of the holes. Thus the inserted timber completely supplies the office of the dislodged portions of the masonry. Another pair of holes is then made, and a second timber introduced, and so on till they are all inserted, and firmly wedged up. The distance at which these are placed must depend upon the weight of the wall. In the case I witnessed the houses were of brick, and the timber stood at the distance, I should think, of three feet apart. All this being done, the intermediate masonry, forming the foundation, may be gradually removed, and a clear space will be left under the supported walls for the reception of the ways.

"There are two more precautions to be attended to; these ways must all be coated with tallow, in a layer of at least half an inch thick, so that the wood of the cradles may never come in contact with them. Some device must also be adopted to prevent the whole affair, house and all, from sliding laterally off. This, Mr. Brown prevents, by cutting along the top of one of the ways a deep groove, into which is fitted a correspondent feather, as it is called, of the superincumbent cradle. This being made to work easy, and well greased, the direct motion is not retarded.

"I have said nothing all this time of the front and back walls; but it will easily be understood how these may be made to rest, like those at the ends, on timbers inserted under the house at right angles, to the first set. The whole of the supporting frame-work is tied so firmly together by bolts, that there is not the slightest bending or twisting of any part of the building.

"When at last the house has reached its destination, a new foundation is built, and the whole process being inverted, the timbers are withdrawn one by one; and such is the security of these operations, that no furniture is ever removed from the houses so transported. The inhabitants, I am told, move out and in as if nothing were going on. This, however, I did not see.*

"Mr. Brown was once employed to remove a house from the top to the bottom of a sloping ground; and, as no additional impulse from screws was here required, he resolved to ease the building down, as sailors call it, by means of a tackle. Unfortunately, about the middle of the operation, the strop of one of the blocks broke, and the operator, who was standing on the lower side of the building, was horrified by the apparition of the house under weigh, and smoking, by its

* We have been credibly informed that, during the operation of moving the house situate at 85 Maiden lane, the Mayor and Corporation, to the amount of 150 individuals, were in the house and partook of refreshments. Also, that, when the church before alluded to was moving, a clergyman delivered a discourse on science, as connected with religion, to a congregation of between 300 and 400 persons.—[Ed. Mec. Mag.]

friction, right down upon him. With that vigorous presence of mind, which is compounded of thorough knowledge, and a strong sense of the necessity of immediate action, and without which courage is often useless, he dashed a crow-bar, which he happened to have in his hand at the time, into a hole accidentally left in one of the ways, and leaping on one side watched the result. The momentum of the enormous moving body was so great that it fairly drove the iron bar, like a cutting instrument, for a considerable distance through the fibres of the timber. The main point, however, was gained, by the house being arrested in its progress down the hill; and the able engineer, like an officer who has shown himself fertile in resource, reaped more credit from the successful application of a remedy to an evil not anticipated, than if all had gone smoothly from the commencement."

Architecture.—Of the Orders of Architecture.

[Continued from page 226.]

The moderns have applied the term order to those architectural forms with which the Greeks composed the façades of their temples.

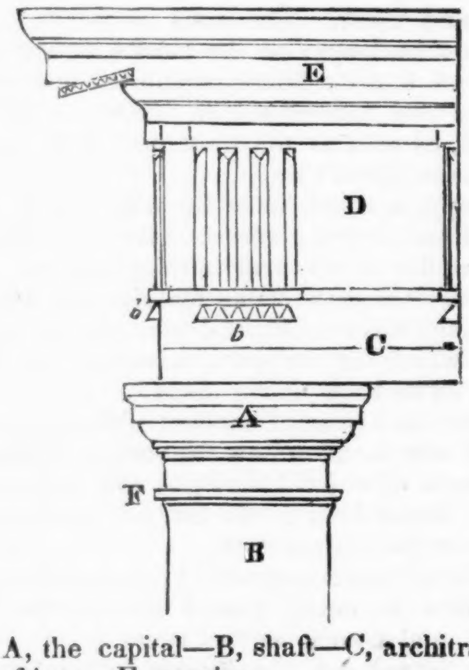
The principal members of an order are, 1st, a platform; 2d, perpendicular supports; and 3d, a lintelling or covering connecting the tops of these supports, and crowning the edifice.

The proportioning of these parts to the edifice and to each other, and at the same time adapting characteristical decorations, constitutes an order, *canon*, or rule.

The principal member of an order is the perpendicular support or *column*. The accompaniments being subservient to this leading feature, the bottom of the column is fixed either on a general artificial platform, or each upon a particular *plinth*, or both. The lower part of the column, which rests upon the square plinth, is sometimes encompassed with mouldings, which, in allusion to their position, are, in conjunction with the plinth, called the *base*.

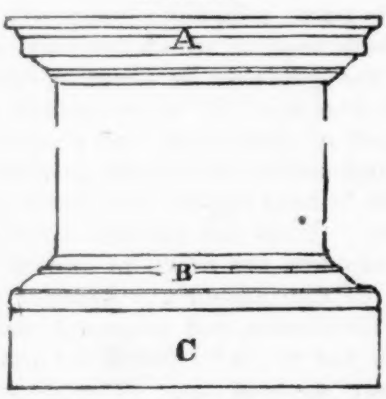
The top part of the column is also covered with a square plinth, with its sides straight or curved, and generally accompanied by circular mouldings or sculptured decorations upon the top part of the column, which is immediately underneath it; this, taken together, is called the capital. The body of the column, which reaches between the base and capital, is termed the *shaft:* it is the frustrum of a cone, with sometimes a plain surface, but frequently having perpendicular flutings, either meeting in an edge or leaving a small plane space between them. The lintelling or covering, which lies upon and connects the column, is termed the *Entablature*, and is sub-divided into three parts, named architrave, frieze, and cornice: the architrave consists of a mere lintel laid along the tops of the columns; the frieze represents the ends of the cross beams resting upon the former, and having the spaces between filled up, having mouldings also fixed to conceal the horizontal joint, and divide it from the architrave; and the upper member or cornice represents the projecting eaves of a Greek roof, showing the ends of the rafters.

These definitions will be easily understood by an inspection of the following figure:



A, the capital—B, shaft—C, architrave—D, frieze—E, cornice

PEDESTAL.



A, the cornice—B, the base—C, the plinth.

Importance of Education to the Practical Artizan.—An opinion both dangerous and pernicious to the mechanics of our country is prevailing among the majority of them. They imagine that literature, science, and general information, are unnecessary to them; and, that if they are acquainted with the commonest rules of arithmetic, reading, writing, and the trade to which they are called, they have all the acquirements their business demands. What have we to do, say they, with polite literature, with history, with the deeper branches of mathematics, the art of composition, eloquence, philosophy, &c.? They have nothing to do with our profession; we are to get our bread by the sweat of the brow; and we leave these branches of education to the ministers, the doctors, and the lawyers of the land.

Now, as long as sentiments like these prevail among mechanics, and the laboring classes of the community, so long they will be doomed to an intellectual and political slavery by the better educated class; so long they are doomed to be stripped of their power, and to be ridden by ambitious and designing men. When mechanics are really convinced that knowledge is power, and that the educated part of society give laws to the rest, they will wake up from their stupor and bestir themselves to get this power into their own hands. It is not the wealthy that rule in our legislative councils, in societies, in politics, in town meetings, and the every day concerns of life; it is not the aristocratic part of the community that have sway over the rest; but it is the educated, the active, the intelligent, who are the emperors and kings of our country: men of superior intelligence, who feel the power within them, and who exert it too to sway the rest.

As matters are now arranged in our country, the lawyers are the only men of whom we have to complain: they get into all the seats of power; give laws to the community, and then set about executing them; they are invested with both the legislative and executive power; the ability to make what laws they please, and the power to execute them as they please; they frame our laws, sit in our councils, are our judges, our justices, our presidents, our governors, our selectmen, our overseers; they creep into every seat of power from the lowest grade, till they reach the last goal of their ambition in the highest office of the gift of the people. The question now arises, from what source do they derive this immense power? Is it from the superior talents of the profession, from superior worth or superior wealth? We think not. This profession is undoubtedly the most intelligent portion of the community; and from this source may be traced all its influence over society in general. Divines and physicians are equally intelligent; but their avocations do not lead them to mingle so much in the business, the uproar, and the excitement of the world; and as they are less active, they consequently have less influence. Lawyers are not only the most intelligent part of the community who mingle in the affairs of the world, but they are far the most active; they exert themselves the most, in order to obtain the most influence.

Mechanics might have this same power,—yea, much more—for the feeling and the majority of the world are on their side; they have an interest too in propping up themselves, in building up their own professions; and now if they had the information to direct their energies aright, they would have within themselves an irresistible influence over the destinies of others. Mechanics do not hold that rank in society they might hold if they pleased, and which they are entitled to hold by the good they do to mankind. But make every mechanic feel the deep necessity of cultivating his mind, and drawing out its hidden treasures; make him feel that his mental power over society, as in fact it does, depends upon the quantity of information he acquires; let him believe that tact and skill, and a knowledge of the human character, are as necessary to him as a knowledge of his tools, and you give that mechanic his due proportion of influence with the world.

But we are stopped at once and told by the mechanic, he has no leisure to cultivate his intellect; his every day avocations demand all his attention and time. It is no such thing. Every man, even the busiest, the most industrious, has leisure enough, if he is disposed to spend that leisure as he ought, instead of whirling it away in trifling and idleness. Put these questions to yourself, and see if you have no leisure. How many evenings do you spend in idleness, in lounging, in useless talk, in beating the streets? How many more hours are devoted to sleep than are necessary for your health? How much of the Sabbath, aside from all hours due to devotion, is entirely wasted, when all might have been spent in reading valuable books? It is a fanciful idea that people have, when they say an education cannot be had without money and teachers.

The idea about the want of time is a mere phantom. Franklin found time in the midst of all his labors to dive into the hidden recesses of philosophy, and to explore an untrodden path of science. The great Frederick, with an empire at his direction, in the midst of war, and on the eve of battles which were to decide the fate of his kingdom, found time to revel in all the charms of philosophy and intellectual pleasures. Bonaparte, with all Europe at his disposal—with kings in his antichamber begging for vacant thrones—with thousands of men whose destinies were suspended on the brittle thread of arbitrary pleasure,—had time to converse with books. Let mechanics, then, make use of the hours at their disposal. They are the life-blood of the community; they can, if they please, hold in their hands the destinies of our republic; they are numerous, respectable, and powerful; they have only to be educated half as well as other professions, to form laws for the nation.

On the Progress of Knowledge. [From Dr. Arnott's Elements of Physics.]

It might be very interesting to show, in minute details, how the arts and civilization have progressed in accordance with the gradual increase of man's knowledge of the universe; but it would lead too far from the main subject. We deem it right, however, to make evident to the student the arousing truths, that the progress is not yet at an end; that it has been vastly more rapid in recent times than ever; and that it seems still to proceed with increasing celerity: and we know not where the Creator has fixed the limits of the change! Although there are thousands of years on the records of the world, our Bacon, who first taught the true way to investigate nature, lived but the other day. Newton followed him, and illustrated his precepts by the most sublime discoveries which one man has ever made. Harvey detected the circulation of the blood only two hundred years ago. Adam Smith, Dr. Black, and James Watt, were friends; and the last, whose steam-engines are now changing the relations of empires, may be said to be scarcely cold in his grave. John Hunter died not long ago; and Herschel's accounts of newly-discovered planets, and of the sublime structure of the heavens, are in the late numbers of our scientific journals: illustrious Britons these, who have left worthy successors treading in their steps. On the continent of Europe, during the same period, a corresponding constellation of genius has shone; and Laplace is now the bright star connecting the future with the past.*

But there is a change going on in the world, connected closely with the progress of science, yet distinct from it, and more important than half of the scientific discoveries: it is the *diffusion of existing knowledge* among the mass of mankind. Formerly knowledge was shut up in convents and universities, and in books written in the dead languages, or in books which, if in the living languages, were so abstruse and artificial, that only a few persons had access to their meaning; and thus, considering the human race as one great intellectual creature, a small fraction only of its intellect was allowed to come into contact with science, and therefore into activity; which fraction, moreover, was often only half exerted, because sufficient motive was wanting. The progress of science in those times was correspondingly slow, and the evils of general ignorance prevailed. Now, however, the strong barriers which confined the stores of wisdom have been thrown down, and a flood overspreads the earth; old establishments are adapting themselves to the spirit of the age; new establishments are arising; the inferior schools are introducing improved systems of instruction; and good books are rendering every man's fire-side a school. From all these causes there is growing up an *enlightened public opinion*, which quickens and directs the progress of every art and science, and, through the medium of a free press, although overlooked by many, is more rapidly becoming the governing influence in all the affairs of man. In Great Britain, partly perhaps as a consequence of its insular situation, which lessened among its inhabitants the dread of hostile invasion, and sooner formed them into a united and compact people, the progress of enlightened public opinion has been more decided than in any other state. The early consequences were more free political institutions; and these have gradually led to greater and greater improvements, until Britain is become an object of admiration among the nations. A colony of her children, imbued with her spirit, now occupies a magnificent territory in the new world of Columbus; and although it has been independent as yet for only half a century, it already counts more people than

* This was written in February, 1827, a few days before the news reached London of the death of this illustrious philosopher.

Spain, and will soon be second to no nation on earth. The example of the Anglo-Americans has aided in rendering their western hemisphere the cradle of other gigantic states, all free, and following, although at a distance, the like steps. In the still more recently discovered continent of Australasia, which is nearly as large as Europe, and is empty of men, colonization is spreading with a rapidity never before witnessed; and that beautiful and rich portion of the earth will also soon be covered with the descendants of free-born and enlightened Englishmen. From thence, still onward, they or their institutions will naturally spread over the vast archipelago of the Pacific Ocean, a track studded with islands of paradise. Such, then, is the extraordinary moment of revolution or transit, in which the world at present exists! And where, we may ask again, has the Creator predestined that the progress shall cease? Thus far at least we know, that he has made our hearts rejoice to see the world filling with happy human beings, and to observe that the increase of the sciences can make the same spot maintain thousands in comfort and god-like elevation of mind, where with ignorance even hundreds had found but a scanty and degrading supply.

The progress of knowledge, which has thus led from former barbarism to present civilization, has gone on by certain remarkable steps, which it is easy to point out; and which it is very useful to consider, because we thereby discover the nature of human knowledge, with the relations and importance of its different branches; and we obtain great facilities for studying science, and for quickening its farther progress.

The human mind, when originally directed to the infinity of objects in the university around it, must soon have discovered that there were resemblances among them; in other words, that the infinity was only a repetition of a certain number of kinds. Among animals, for instance, it would distinguish the sheep, the dog, the horse; among vegetables, the oak, the beech, the pine; among minerals, lime, flint, the metals, and so forth. And becoming aware that by studying an exemplar of each kind, its limited power of memory might acquire a tolerably correct knowledge of the whole, while this knowledge would enable the possessors more easily to obtain what was useful to them, and to avoid what was hurtful, the desire for such knowledge must have arisen with the first exercise of reason. Accordingly, the pursuit of it has been unremitting, and the labor of ages has at last nearly completed an arrangement of the constituent materials of the universe, under three great classes of Minerals, Vegetables, and Animals, commonly called the *three kingdoms of nature*, and of which the minute description is termed Natural History: and museums of natural history have been formed, which contain a specimen of almost every object included in these classes, so that, now, a student within the limits of an ordinary garden, may be said to be able to examine the whole of the universe.

Books.—Nothing in this world, except the Christian religion, is probably so much abused as books. To say nothing of the pollution and death spread far and wide by books made and circulated by bad men, those made and used with the best designs and intentions very often act as so many opaque substances, placed directly between the mind and the objects they attempt to present to it. They wholly intercept the light reflected directly from *things* themselves, for the miserable substitutes of unmeaning *signs* of things. A better example to illustrate this position is perhaps not necessary, than the very first instance in which children are called away from things to the scene of their *education*, under the dreadful *abuse* of that term in its frequent, perhaps common application. We refer to the time when children are taken from their homes, from the nursery, the kitchen, the gardens, the yards, and the fields, where they are surrounded with the beautiful and useful objects of nature and art, which give full scope and exercise to their eager and active minds and susceptible hearts, and are put into that dismal place of confinement, the school room, with no other employment, but to 'say A and B, and sit on a bench.' We may bring the *unlettered* savage to illustrate the same position; for it is a fact well known to those acquainted with these specimens of nature, that they have a better knowledge of their minerals, their vegetables, their animals, and their geography, than the boasting people of New-England have of theirs. Almost any native of the forest will delineate, with great exactness, the boundaries, the rivers and brooks, the mountains, hills, and forests, of the country which is the scene of his travels and his interests, and the field of his possessions and his rights.

On the other hand, no class of men are so *unfortunately* ignorant as those whose *educa-*

tion has been restricted to the school room, the college, and the library. Each exerts to its full extent the *opaque* property of planks, slabs, bricks, and pasteboard, to shut out from the mind the light and the knowledge of things and of *common sense.* No class of men in the community are more useless, (we wish they were merely useless,) than those thus educated. As politicians they are visionary and utopian, and yet ambitious and overbearing, and, of course, dangerous; as lawyers they are insinuating, indolent, and yet disturbers of the peace of neighborhoods and families; as physicians, they are rash, injudicious, and frequently murderous; as clergymen, they are dogmatical, pretending, and often tyrannical over the common sense and consciences of men; and as members of the great family of man, they are to a great extent so many blots in the cheerful and harmonious creation of God.

If we wished to *educate* a child into a being perfectly useless to the world or to himself, we would put him at an early age into the schools of a city, and carry him through the several grades, occupying eight or ten years, and then send him to a college, either in the city or the one the nearest to it, and we should be almost sure of gaining our point. He would be able to repeat all the signs which the Greeks and Romans used for ideas, and use them for shutting all ideas out of his own mind. He would be likely to collect the syllogysms, the dogmas and the mysticisms of all the institutions which have diffused darkness through other ages and countries, and completely envelope himself, and perhaps many around him, in the same darkness. He might repeat, in numberless and beautiful technicalities, the laws and the operations of matter and of mind,—aye, and the arts, too,—without knowing whether he was indebted for his bread to the tiller of the field, or the worker in metals. He might still be at a loss whether to put the horse before the cart, or cart before the horse. We have instances thick around us of those whose *book education* is complete, and more than complete, (the stick is so much straightened as to be made crooked, the post is *made* more than perpendicular,) who are yet as ignorant of men and things, and of course of the proper modes of promoting or sustaining their various relations and interests, as if they had been educated by and for the inhabitants of another planet —as if they were on their first visit to our globe, from the Moon or Venus.

We do not intend, by these remarks, that books ought to be used for bonfires, or that they ought to be thrown into disuse; we mean that they, like christianity, ought to be properly used, not abused; we mean that as christianity ought to promote love, not hatred, so books ought to promote knowledge, not ignorance—to enlighten, not obscure the mind—to lead their pupils to observe, and to study men and things, not to shut them away from them—to cultivate common sense, not to destroy it—to aid in cultivating the germ of immortality, implanted in every mind and heart, into a tree which shall spread its branches, and scatter the fruits of intelligence and christianity through boundless space and endless ages.

Mind and Heart.—The laws and powers of mind and heart, and their influence and action upon each other, present more that is curious, grand, and important, than any other subject beneath the sun. The mind and heart, or the intellect and affections, each possesses various powers, and the powers of each are essential to the other. Feeling, or affection without intellect, could not raise a being above the brutes; and mere intellect without feeling must leave a being without moral character. The possession of both, and the disciplined or well-regulated action of one upon the other, constitute true excellence of character. The intellect discovers truth, and the feelings urge the being to pursue it. The intellect distinguishes between right and wrong, and the affections lead to the pursuit of the one and the avoiding of the other; or where the intellect is entirely under the control of the passions or feelings, the individuals may perceive the right, but pursue the wrong. The intellect of the drunkard lays fully before him the evils and ruin he is bringing upon himself and his family, by pursuing his cups, and yet he may be so entirely under the control of his passions or appetites, as to suffer his intellect to have no voice in directing his steps, but in spite of her intreaties he rushes headlong to destruction, and brings poverty, wretchedness, and disgrace, upon a wife and children, for whom he would before have been ready to sacrifice his life.

It is evident, then, that a man wholly under the control of feeling, or passion, of any kind, may become a brute or a monster, a sot, or debauchee, a highway robber, a murderer, a public butcher of his own species.

On the other hand, if intellect is the only power called into exercise, while it may lead to much abstract truth, it will do little or nothing to embody that truth in living actions—i. e. apply it to its uses. It may be making constant progress in unfolding the laws of the physical, the intellectual, and even the moral world, without applying one of those laws for the benefit of his fellow men. Though such a being may be a philosopher, he is a cold philosopher—an intellectual miser; bording up materials which neither himself nor any one else can use, except in the selfish and miserly reflection, that they are in his possession.

But when all the powers of the intellect, and all the feelings of the heart, are brought into a vigorous and healthy operation, the one exerting its proper influence upon the other, they indeed present a specimen of "the noblest work of God"—a being worthy of God and himself—a character which the cold philosopher must approve and admire, though he cannot imitate; which the abandoned debauchee must respect, though he may hate. Such a character is a *Christian philosopher*.

Facts in Physics.—Gold beaters, by hammering, reduce gold to leaves so thin that 282,000 must be laid on each other to produce the thickness of an inch. They are so thin, that, if formed into a book, 1500 would occupy the space of a single leaf of common paper.

A grain of blue vitriol, or carmine, will tinge a gallon of water, so that in every drop the color may be perceived; and a grain of musk will scent a room for twenty years.

A stone, which on land requires the strength of two men to lift, may be lifted in water by one man.

A ship draws less water by one thirty-fifth in the heavy salt water than in the water of a river, and a man may support himself more easily in the sea than in a river.

An immense weight may be raised a short distance by first tightening a dry rope between it and a support, and then wetting the rope. The moisture imbibed into the rope by capillary attraction causes it to become shorter.

A rod of iron which, when cold, will pass through a certain opening, when heated expands, and becomes too thick to pass. Thus the tire or rim of a coach wheel when heated goes on loosely, and when cooled it binds the wheel most tightly.

One pint of water converted into steam fills a space of nearly 2000 pints, and raises the piston of a steam engine with a force of many thousand pounds. It may afterwards be condensed and re-appear as a pint of water.

A cubic inch of lead is forty times heavier than the same bulk of cork. Mercury is nearly fourteen times heavier than the same bulk of water.

Sound travels in water about four times quicker, and in solids from ten to twenty times quicker than in air.

Excellence not limited by Station.—There is not a more common error of self-deception than a habit of considering our stations in life so ill-suited to our powers as to be unworthy of calling out a full and proper exercise of our virtues and talents.

As society is constituted there cannot be *many* employments which demand very brilliant talents, or great delicacy of taste, for their proper discharge. The great bulk of society is composed of plain, plodding men, who move "right onwards" to the sober duties of their calling. At the same time the universal good demands that those whom Nature has greatly endowed should be called from the ordinary track to take up higher and more ennobling duties. England, happily for us, is full of bright examples of the greatest men raised from the meanest situations; and the education which England is now beginning to bestow upon her children will multiply these examples. But a partial and incomplete diffusion of knowledge will also multiply the victims of that evil principle which postpones the discharge of present and immediate duties, for the anticipations of some destiny above the labors of a handicraftsman, or the calculations of a shop-keeper. Years and experience, which afford us the opportunity of comparing our own powers with those of others, will, it is true, correct the inconsistent expectations which arise from a want of capacity to set the right value on ourselves. But the wisdom thus gained may come too late. The object of desire may be found decidedly unattainable, and existence is then wasted in a sluggish contempt of present duties; the spirit is broken; the temper is soured; habits of misanthropy and personal neglect creep on; and life eventually becomes a tedious and miserable pilgrimage of never-satisfied desires. Youth, however, is happily not without its guide, if it will take a warning

from example. Of the highly gifted men whose abandonment of their humble calling has been the apparent beginning of a distinguished career, we do not recollect an instance of one who did not pursue that humble calling with credit and success until the occasion presented itself for exhibiting those superior powers which Nature occasionally bestows. Benjamin Franklin was as valuable to his master, as a printer's apprentice, as he was to his country as a statesman and a negotiator, or to the world as a philosopher. Had he not been so, indeed, it may be doubted whether he ever would have taken his rank among the first statesmen and philosophers of his time. One of the great secrets of advancing in life is to be ready to take advantage of those opportunities which, if a man really possesses superior abilities, are sure to present themselves some time or other. As the poet expresses it, "There is a *tide* in the affairs of men,"—an ebbing and flowing of the unstable element on which they are born,—and if this be only "taken at the flood," the "full sea" is gained on which "the voyage of their life" may be made with ease and the prospect of a happy issue.

But we should remember, that, for those who are not *ready* to embark at the moment when their tide is at its flood, that tide may never serve again; and nothing is more likely to be a hindrance at such a moment than the distress which is certain to follow a neglect of our ordinary business.

Geometrical Diagrams.—The sheet of geometrical diagrams published in Boston, and recently improved, many thousands of which are in use in families and schools, have the following advantages:

1. They give children at first correct names of things, and thus avoid the necessity of their *unlearning*. 2. They furnish an interesting and continued employment to children. 3. They give a useful exercise to their hands, eyes, judgment, and taste. 4. They make children happy, by a useful as well as agreeable exercise of their various faculties. 5. They relieve mothers and teachers from the uneasiness and consequent teazing of children. 6. They prevent mischief done by children, when left to seek their own employment, such as trying experiments on crockery, tables, chairs, and other furniture. 7. They answer instead of the "*birch*" to keep children orderly. 8. They learn children to *think*, to *compare*, to *discriminate*, instead of looking *vaguely* and carelessly at things. 9. They interest children, in the family and school apparatus which they accompany, in arithmetic, geography, and in all their studies, especially writing, whether at school or at home. 10. They furnish, more than any thing else, the elements of the whole circle of the sciences and the arts, such as Natural Philosophy, Astronomy, Chemistry, Mineralogy, Surveying, Navigation, Drawing, Measuring surfaces and solids, such as boards, cloth, land, wood, timber, walls, casks, cisterns, bins, &c. &c. They are more economical than any thing else for which 12 1-2 cents can be paid.

Boundlessness of the Creation.—About the time of the invention of the telescope, another instrument was formed, which laid open a scene no less wonderful, and rewarded the inquisitive spirit of man. This was the microscope. The one led me to see a system in every star; the other leads me to see a world in every atom. The one taught me that this mighty globe, with the whole burden of its people and its countries, is but a grain of sand on the high field of immensity; the other teaches me that every grain of sand may harbor within it the tribes and families of a busy population. The one told me of the insignificancy of the world I tread upon. The other redeems it from all insignificancy; for it tells me that in the leaves of every forest, and in the flowers of every garden, and in the waters of every rivulet, there are worlds teeming with life, and numberless are the glories of the firmament. The one has suggested to me, that beyond and above all that is visible to man, there may be fields of creation which sweep immeasurably along, and carry the impress of the Almighty's hand to the remotest scenes of the universe; the other suggests to me, that within and beyond all that minuteness which the aided eye of man has been able to explore, there may be a region of invisibles; and that, could we draw aside the mysterious curtain which shrouds it from our senses, we might see a theatre of as many wonders as astronomers have unfolded, a universe within the compass of a point so small as to elude all the powers of the microscope, but where the wonder-working God finds room for all his attributes, where he can raise another mechanism of worlds, and fill and animate them all with the evidence of his glory.—[Chalmers.]

Fire Proof Cement.—The French cement for the roofs of houses, to preserve the wood and protect it from fire, is made in the following manner:

Take as much lime as is usual in making a pot full of whitewash, and let it be mixed in a pail full of water; in this put two and a half pounds of brown sugar, and three pounds of fine salt; mix them well together, and the cement is completed. A little lamp-black, yellow ochre, or other coloring commodity, may be introduced to change the color of the cement, to please the fancy of those who use it. It has been used with great success, and been recommended particularly as a protection against fire. Small sparks of fire, that frequently lodge on the roofs of houses, are prevented by this cement from burning the shingles. So cheap and valuable a precaution against the destructive element ought not to pass untried. Those who wish to be better satisfied of its utility can easily make the experiment, by using on a small temporary building—or it may be tried by shingles put together for the purpose, and then exposed to the fire.

Disappointments of the Authors of Important Improvements.—Almost every one who has rendered a great service to mankind, by striking out inventions, whose objects are misconceived or imperfectly misunderstood by the world, has had to complain of the neglect or coldness of his own generation. Even his best friends are apt to suspect his motives and undervalue his labors. The real recompense in such circumstances, as in all others, is the consciousness of doing one's duty. Fulton, the inventor of the steamboat in North America, which, in a few years, has produced such an astonishing change in that vast country, by connecting together its most distant states, sustained the mortification of not being comprehended by his countrymen. He was, therefore, treated as an idle projector, whose schemes would be useless to the world and ruinous to himself. At a discourse delivered at the Mechanics' Institute, Boston, in 1829, by Judge Story, the feelings of Fulton, upon his first public experiment, are thus related:

"I myself have heard the illustrious inventor of the steamboat relate, in an animated and affecting manner, the history of his labors and discouragements. When, said he, I was building my first steamboat at New-York, the project was viewed by the public either with indifference or with contempt, as a visionary scheme. My friends, indeed, were civil, but they were shy. They listened with patience to my explanations, but with a settled cast of incredulity on their countenances. I felt the full force of the lamentation of the poet,

> 'Truths would ye teach, to save a sinking land,—
> All shun, none aid you, and few understand.'

As I had occasion to pass daily to and from the building yard, while my boat was in progress, I have often loitered unknown near the idle groups of strangers, gathering in little circles, and hearing various inquiries as to the object of this new vehicle. The language was uniformly that of scorn, or sneer, or ridicule. The loud laugh often rose at my expense: the dry jest; the wise calculation of losses and expenditures; the dull but endless repetition of the Fulton Folly. Never did a single encouraging remark, a bright hope, or a warm wish, cross my path. Silence itself was but politeness, veiling its doubts, or hiding its reproaches. At length the day arrived when the experiment was to be put into operation. To me it was a most trying and interesting occasion. I invited my friends to go on board to witness the first successful trip. Many of them did me the favor to attend, as a matter of personal respect; but it was manifest that they did it with reluctance, fearing to be the partners of my mortification, and not of my triumph. I was well aware, that, in my case, there were many reasons to doubt of my own success. The machinery was new and ill made; many parts of it were constructed by mechanics unaccustomed to such work; and unexpected difficulties might reasonably be presumed to present themselves from other causes. The moment arrived in which the word was to be given for the vessel to move. My friends were in groups on the deck. There was anxiety mixed with fear among them. They were silent, and sad, and weary. I read in their looks nothing but disaster, and almost repented of my efforts. The signal was given, and the boat moved on a short distance, and then stopped, and became immovable. To the silence of the preceding moment now succeeded murmurs of discontent, and agitations, and whispers, and shrugs. I could hear distinctly repeated, 'I told you it would be so, it is a foolish scheme; I wish we were well out of it.' I elevated myself upon a platform, and addressed the assembly. I stated that I knew not what was the matter; but if they would be quiet, and indulge me for half an hour,

I would either go on or abandon the voyage for that time. This short respite was conceded without objection. I went below, examined the machinery, and discovered that the cause was a slight mal-adjustment of some of the work. In a short period it was obviated. The boat was again put in motion. She continued to move on. All were still incredulous. None seemed willing to trust the evidence of their senses. We left the fair city of New-York; we passed through the romantic and ever varying scenery of the Highlands; we descried the clustering houses of Albany; we reached its shores; and then, even then, when all seemed achieved, I was the victim of disappointment. Imagination superceded the influence of fact. It was then doubted if it could be done again; or if done, it was doubted if it could be made of any great value."

Sinking Wells.—Bishop Heber mentions a curious way of sinking wells in some parts of Asia. When the ground is sandy, a cylindrical tower of brick or stone work is made of the intended size of the well. This is suffered to remain until the masonry becomes indurated, and then it is gradually undermined until it is sunk even with the surface of the ground. If the well is not sufficiently deep, they add more masonry, and again undermine.

Canals.—The annexed account of an interesting experiment, with reference to accelerating the movement of boats on canals, will be found worthy the attention of those who take a direct interest in the concerns of Internal Improvement. In canals, as used in this country, speed may perhaps be of less consequence than regularity in transmission of freight, though certain it is, that, in almost all transactions, time is money:

Accelerated Movement upon Canals.—In England, recently, a trial was made upon the Paddington Canal, of the new canal-boat. The object of the trial was to show that a boat built in a different form, and constructed of other materials than the ordinary canal-boat, might, by using superior horses, be drawn along the water at the rate of ten miles or more in an hour, instead of two miles an hour, the pace of the boats now in use. The day was remarkably fine. The portion of the canal more particularly appropriated to the experiment was from the third to the seventh mile from Paddington. The boat was constructed of sheet-iron, rivetted hot. It was 70 feet long, by 5½ feet wide, and painted green and white. The boat was provided with an awning made of white twilled cotton cloth, which had been rendered semi-transparent with oil. The awning was so set up that the top was extended over light wooden arches, which rested upon a thin upright frame of rod iron; and the sides, in the form of curtains, were made to slide at pleasure upon paralleled rods placed at the upper and lower ends of the curtains. The rudder was of a single sheet of iron, of about a yard in length, and it was moved by a tiller made of about two yards of stout rod iron. Two steady hunting horses, each mounted by a lad, and the two harnessed to a towing rope of about 150 feet in length, constituted the moving power. The number of persons on board the boat was 48, including the crew, the gentlemen making the experiment, some of the principal members of the Grand Junction Company, and the visiters, amongst whom were Mr. Telford, Mr. Babbage, Captain Basil Hall, Mr. Hellyer, and Mr. Gill; a lady also made one of the party on this interesting occasion. Certain distances were measured on the canal bank, and marks set up at the ends of them. At each of these places, also, a man was stationed with a guaged rod in his hand, which he so held, as that, upon the boat's passing, he might instantly read off the height of the wave caused by the disturbance of the water. When all things were ready on the shore, and the party had embarked, the boat was put in motion. The speed from one station to another, taken by seconds' watches, showed, for some time, a progress at the rate of thirteen miles an hour. The horses, however, soon began to tire, and the speed fell to eleven, and ultimately, in returning for the third time, to ten and a quarter miles in the hour.

The experiment, as far as it goes was attended with complete success. The motion is the easiest imaginable. The boat glides along the water so smoothly and noiselessly, that its progress is all but imperceptible to those on board whose attention is not extended to external objects. A relay of horses will be required at the end of every four or five miles. The banks of the canal will have to be edged for nine or ten inches above the ordinary level of the water with hard materials, and the towing-path to be slightly sloped outwards. Improvements, no doubt, will also be made to facilitate the passing of locks, and in the mode of attaching the horses to the boat, so that the animals may exert their

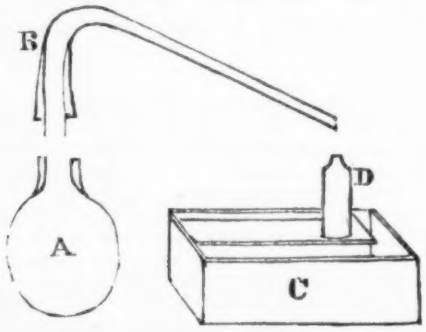
power upon the boat disembarrassed of the awkwardness of the direction in which, under the present form of towing, they are made to put forth their strength.—[London Albion.]

Science preceding Art.—When the principles of any science are become common to all the world, these principles lead to inventions, nearly, if not altogether similar, by different persons having no communication with each other. A remarkable instance of this is given by Judge Story, in his address to the Boston Mechanics' Institute:

"A beautiful improvement has been made in the double-speeder of the cotton spinning machine by one of our ingenious countrymen. The originality of the invention was established by the most satisfactory evidence. The defendant, however, called an Englishman as a witness, who had been a short time in the country, and who testified most explicitly to the existence of a like invention in the improved machinery in England. Against such positive proof there was much difficulty in proceeding. The testimony, though doubted, could not be discredited; and the trial was postponed to another term, for the purpose of procuring evidence to rebut it. An agent was despatched to England for this and other objects; and, upon his return, the plaintiff was content to become nonsuited. There was no doubt that the invention here was without any suspicion of its existence elsewhere; but the genius of each country, almost at the same moment, accomplished, independently, the same achievement."

History of Chemistry. [Continued from No. 5, page 229.]

Of Oxygen Gas.—Oxygen gas may be obtained by the following process:



Procure an iron bottle of the shape A, and capable of holding rather more than an English pint. To the mouth of this bottle an iron tube bent like B is to be fitted by grinding. A gun-barrel deprived of its butt end answers the purpose very well. Into the bottle put any quantity of the black oxide of manganese* in powder; fix the iron tube into its mouth, and the joining must be air tight; then put the bottle into a common fire, and surround it on all sides with burning coals. The extremity of the tube must be plunged under the surface of the water with which the vessel C is filled.

This vessel may be of wood or japanned tin plate. It has a wooden shelf running along two of its sides, about three inches below the top, and an inch under the surface of the water. In one part of this shelf there is a slit, into which the extremity of the iron tube plunges. The heat of the fire expels the greatest part of the air contained in the bottle. It may be perceived bubbling up through the water of the vessel C from the extremity of the iron tube. At first the air bubbles come over in torrents; but after having continued for some time, they cease altogether.

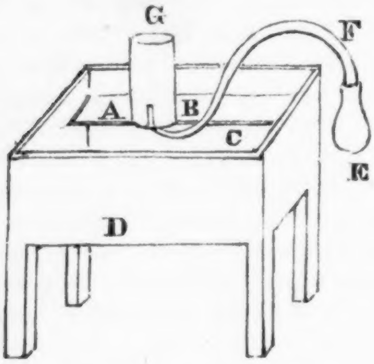
Meanwhile the bottle is becoming gradually hotter. When it is obscurely red the air bubbles make their appearance again, and become more abundant as the heat increases. This is the signal for placing the glass jar D, open at the lower extremity, previously filled with water, so as to be exactly over the open end of the gun-barrel. The air bubbles ascend to the top of the glass jar D, and gradually displace all the water. The glass jar D then appears to be empty, but is in fact filled with air. It may be removed in the following manner: Slide it away a little from the gun-barrel, and then dipping any flat dish into the water below it, raise it on the dish and bear it away. The dish must be allowed to retain a quantity of water in it, to prevent the air from escaping. Another jar may then be filled with air in the same manner; and this process may be continued either till the manganese ceases to give out air, or till as many jars-full have been obtained as are required.† This method of obtaining and confining air was first invented by Dr. Mayou, and afterwards much

* This substance shall be afterwards described. It is now very well known in Britain, as it is in common use with bleachers, and several other manufacturers, from whom it may be easily procured.

† For a more exact description of this and similar apparatus, the reader is referred to Lavoisier's *Elements of Chemistry*, and Priestley *on Airs*; and above all, to Mr. Watt's description of a *pneumatic apparatus*, in Beddoo's *Considerations on Factitious Airs.*

improved by Dr. Hales. All the air obtained by this or any other process, or, to speak more properly, all the airs differing in their properties from the air of the atmosphere, have, in order to distinguish them from it, been called gasses; and this name we shall afterwards employ.*

Oxygen gas may also be obtained in a different manner, thus: Let D represent a



wooden trough, the inside of which is lined with lead or tinned copper; and let C be a cavity in the trough, which ought to be a foot deep. The trough is to be filled with water at least an inch above the shelf A B, which runs along the inside of it, about three inches from the top. In the body of the trough, which may be called the cistern, the jars destined to hold gas are to be filled with water, and then to be lifted, and placed inverted upon the shelf at B.

This trough, which was invented by Dr. Priestley, has been called by the French chemists the *pneumato-chemical*, or simply *pneumatic* apparatus, and is extremely useful in all experiments in which gasses are concerned. Into the glass vessel E put a quantity of black oxide of manganese in powder, and pour over it as much of that liquid which in commerce is called *oil of vitriol*, and in chemistry *sulphuric acid*, as is sufficient to form the whole into a thin paste; then insert into the mouth of the vessel the glass tube F, so closely that no air can escape except through the tube. This may be done either by grinding, or by covering the joining with a little glazier's putty, and then laying over it slips of bladder or linen dipped in glue, or in a mixture of the white of eggs and quick-lime. The whole must be made fast with cord.

The end of the tube F is then to be plunged into the pneumatic apparatus D, and the jar G, previously filled with water, to be placed over it on the shelf. The whole apparatus being fixed in that situation, the glass vessel E is to be heated by means of a lamp or candle. A quantity of oxygen gas rushes along the tube F, and fills the jar G. As soon as the jar is filled, it may be slid to another part of the shelf, and other jars substituted in its place, till as much gas has been obtained as is wanted. The last of these methods of obtaining oxygen gas was discovered by Scheele, the first by Dr. Priestley.

The gas obtained by the above processes was discovered by Dr. Priestley on the 1st of August, 1774, and called by him *dephlogisticated air*. Mr. Scheele, of Sweden, discovered it before 1777, without any previous knowledge of what Dr. Priestley had done: he gave it the name of *empyreal air*.* Condorcet gave it first the name of *vital air*; and Mr. Lavoisier afterwards called it *oxygen gas*: a name which is now generally received, and which we shall adopt.

1. Oxygen gas is colorless, and invisible like common air. Like it, too, it is elastic, and capable of indefinite expansion and compression.

2. If a lighted taper be let down into a phial filled with oxygen gas, it burns with such splendor that the eye can scarcely bear the glare of light, and at the same time produces a much greater heat than when burning in common air. It is well known that a candle put into a well closed jar, filled with common air, is extinguished in a few seconds. This is also the case with a candle in oxygen gas; but it burns much longer in an equal quantity of that gas than of common air.

It has been ascertained by experiment, which shall be afterwards related, that atmospherical air contains 22 parts in the hundred (in bulk) of oxygen gas; and that no sub-

* The word gas was first introduced into Chemistry by Van Helmont. He seems to have intended to denote by it every thing which is driven off from bodies in a state of vapors by heat.

* This process, by which the joinings of vessels are made air tight, is called *luting*, and the substances used for that purpose are called *lutes*. The lute most commonly used by chemists, when the vessels are exposed to heat, is fat lute, made by beating together, in a mortar, fine clay and boiled linseed oil. Bees-wax, melted with about one eighth part of turpentine, answers very well, when the vessels are not exposed to heat. The accuracy of chemical experiments depends almost entirely in many cases upon securing the joinings properly with luting. The operation is always tedious; and some practice is necessary before one can succeed in luting accurately. Some very good directions are given by Lavoisier. See his *Elements*, Part iii. chap. 7. In many cases luting may be avoided altogether, by using glass vessels properly fitted to each other by grinding them with emery

stance will burn in common air previously deprived of all the oxygen gas which it contains. But combustibles burn with great splendor in oxygen gas, or in other gasses to which oxygen has been added. Oxygen gas, then, is absolutely necessary for combustion.

It has been proved also, by many experiments, that no breathing animal can live for a moment in any air or gas which does not contain oxygen gas mixed with it. Oxygen gas, then, is absolutely necessary for respiration.

When substances are burned in oxygen gas, or in any other gas containing oxygen, if the air be examined after the combustion, we shall find that a great part of the oxygen has disappeared. If charcoal, for instance, be burned in oxygen gas, there will be found, instead of part of the oxygen, another very different gas, known by the name of carbonic acid gas. Exactly the same thing takes place when air is respired by animals; part of the oxygen gas disappears, and its place is occupied by substances possessed of very different properties. Oxygen gas then undergoes some change during combustion, as well as the bodies which have been burned; and the same observation applies also to respiration.

Oxygen gas is somewhat heavier than common air. If the specific gravity of common air be reckoned 1·000, that of oxygen gas, as determined by Mr. Kirwan, is 1·103. With this result the statement of Lavoisier agrees exactly. But Mr. Davy found it a little heavier; and Fourcroy, Vauquelin, and Seguin, found it a little lighter. Its specific gravity, according to Mr. Davy's experiments, is 1·127*: according to the French chemists, 1·087.

At the temperature of 60 degrees, and when the barometer stands at 30 inches, 100 cubic inches of common air weigh very nearly 31 grains; and 100 cubic inches of oxygen gas, at the same temperature and pressure, weigh, according to Mr. Kirwan and Lavoisier, 34 grains; according to Sir H. Davy, 34·74 grains.

Oxygen gas is not sensibly absorbed by water, except under great pressure; but by forcing it into a bottle of water by strong pressure, it may be made to absorb half its bulk of that gas, and to retain it in solution. Water thus impregnated does not sensibly differ from common water, either in taste or smell. It has been found a valuable remedy in several diseases.

Oxygen is capable of combining with a great number of bodies, and of forming compounds possessed of very different qualities.

As the combination of substances with each other is of the utmost importance in chemistry, we shall here make a few observations on that subject before we proceed to the consideration of the nature and properties of *Hydrogen Gas*.

When common salt is thrown into a vessel of pure water, it melts, and very soon spreads itself through the whole of the liquid, as any one may convince himself by the taste. In this case the salt combines with the water, and cannot afterwards be separated by filtration, or any other mechanical means. It may, however, be done by a very simple process; for if a quantity of the spirit of wine be poured into the solution, the salt will fall slowly to the bottom of the vessel in the state of a very fine powder.

It was long ago asked, why does the salt dissolve in water? and also, why does it fall to the bottom on pouring in spirit of wine? These questions were first answered by Sir Isaac Newton.

There is a certain attraction between the particles of common salt and those of water, which causes them to unite together whenever they are presented to one another. There is also an attraction between the particles of water and spirit of wine, which equally disposes them to unite, and this attraction is greater than that between the water and the salt; the water, therefore, leaves the salt to unite with the spirit of wine; and the salt being now unsupported, falls down by its weight to the bottom of the vessel. This power, which disposes the particles of different bodies to unite, was called by Newton *attraction*, by Bergman *elective attraction*, and by many of the German and French chemists *affinity;* and this last term is now employed in preference to others, because they are rather general. All substances which are capable of combining together, are said to have an *affinity* for each other; on the contrary, those substances which do not unite are said to have no affinity for each other. Thus, oil and water are said to have no affinity for one another.

It appears, from the instance of the common salt and spirit of wine, that substances

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* Mr. Davy's oxygen gas was procured from oxide of manganese. It is possible that it contained a little *carbonic acid gas*. The tests used would not have excluded that body. This would explain its greater specific gravity.

differ considerably in the degree of their affinity from other substances, for the spirit of wine displaced the salt, and united with the water. Spirit of wine has, therefore, a stronger affinity for water than common salt has.

From facts of this kind tables of affinity have been formed and arranged in a very peculiar manner. The substance whose affinities are to be represented, is placed at the top of a column; and beneath it the bodies for which it has an attraction, placing those nearest to it which it attracts most strongly. Thus, in exhibiting the affinities of muriatic acid, the bodies for which it has an affinity would be placed thus:

MURIATIC ACID.

—

Barytes,
Potash,
Soda, &c.

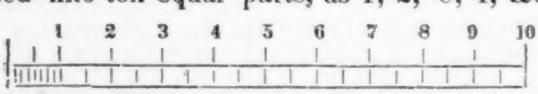
This method is now universally adopted, and has contributed very much to the rapid progress of chemistry.

We shall treat this subject fully in a future number: we introduce it here merely to give the student of chemistry some idea of what is meant by bodies combining together, as the expression will frequently occur even in treating of simple bodies.

Gunter's Scale. By G. A. Seares. [From the London Mechanics' Magazine.]

Mr. Editor,—The great difficulty in the use of Gunter seems to be in taking from the scale three or more figures; now, in order to thoroughly understand how this is performed, I will first show how, from any plane scale of *equal parts*, decimally devided, we are able to do this.

Let a line, as represented below, be divided into ten equal parts, as 1, 2, 3, 4, &c.



and let one part be supposed divided again into ten equal parts (and all the rest similarly divided), it is plain that each large division will be a unit, or the tenth part of the whole line, and each small division the tenth of a unit; now, if the scale is long enough, each of these *small* divisions may be divided again into ten equal parts, which parts will be the *tenth of the tenth* of a unit, or the hundredth part of a unit.

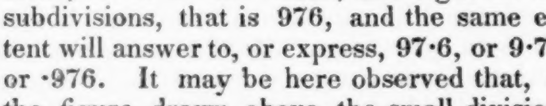
Now, if, instead of calling the whole line *ten*, we call it an *hundred*, the large divisions will then be *tens*, the small divisions *units*, and the subdivisions (if the scale is long enough to admit it) *tenths of units;* in the same manner, if the whole line is called a *thousand*, the large divisions will be each a *hundred*, the small divisions *tens*, and the subdivisions *units*.

It is thus plain that the same scale will answer for either one *unit* with three decimals, one *ten* with two decimals, one *hundred* with one decimal, or one *thousand* without any decimal: thus you may take off from the scale (if long enough) all numbers from ·0001 to 1000.

Example. Suppose it was required to take an extent from the scale, with your compasses, answering to 976.

Here your highest denomination is hundreds; therefore the large divisions stand for *hundreds*, the small ones for *tens*, and the subdivisions *units*. Therefore, setting one leg at the beginning of your scale, open your compasses equal to nine of the large divisions, seven of the small, and eight of the subdivisions, that is 976, and the same extent will answer to, or express, 97·6, or 9·76, or ·976. It may be here observed that, in the figure drawn above, the small divisions are not drawn throughout the whole length of the scale, as it would cause confusion, and the subdivisions are not marked, as in such a small scale it would have been impossible; but they may be conceived to be drawn and estimated with ease in a scale sufficiently extended.

We will now show how, from this scale of equal parts, we may *add* or *subtract* any number from another, and also find an arithmetical mean between any two numbers; in order to do which, it will be convenient to lay down, on another similar scale, the above line, as in the annexed figure (but too small to show the small divisions or subdivisions), which is analogous to Gunter's line of numbers, which is two scales marked from one to ten, but not of equal divisions; whereas this is marked from one to ten, and repeated, being all equal divisions.



Let us illustrate this by an example in each case.

Example 1. Let it be required to add 749 to 856.

Here we have the greatest denomination *hundreds;* therefore the great divisions are hundreds, the small ones tens, and the sub-

divisions units; now find, in the left hand scale, 8, which is 800, and 5 in the small divisions, which is five tens, or 50; and between that and the next small division, take six of the subdivisions, which is six units, expressing 856. Now, this is the point on which to place one leg of the compasses; then, in the same manner, open the compasses to the extent 749, and with that extent, with one leg at the point 856 (as found), the other leg will reach to 6 in the right hand scale, (which, as we make every large division 100, will be 1000 + 600, or 1600,) and not quite to the first small division, which is 0; and in the subdivisions the leg of the compasses will coincide on that which is the fifth subdivision from the 6; thus we have 1000 + 600 + 0 + 5, that is, 1605, the correct answer. And thus we may add any two numbers whose sum shall not exceed 2000; and if a third scale had been added, we might have done the same to 3000, and so on.

Example 2. Let it be required to subtract 749 from 856.

Find the point 856, as in the last example, and take the distance 749 in your compasses, and you will find, if you extend the other leg towards the beginning of the scale, it will rest between the point 1, which is 100, and not reach the next division, marked the tens, consequently 0 tens, but rest on the subdivision, showing seven units, that is, 100 + 0 + 7 = 107, the answer.

Example 3. Let it be required to find an arithmetical mean (that is, half the sum) between 856 and 749.

Find the sum of the two numbers, as shown in example 1; then half that distance in the scale, which may be found by trial with the compasses, will be found to be between 8 and 9 in the large divisions, which shows the first figure to be 800, and between the first small division and 0, which shows 0 tens, and between 2 and 3 of the subdivisions, which is two units; but, as it does not exactly agree with that point, we can easily estimate the distance between 2 and 3, where the compasses fall, which is half way; therefore we have the half of an unit, or 1-2 or ·5: thus we have 800 + 0 + 2 + ·5 =802·5, the correct answer.

Note.—It may be here observed, that as the scales most generally in use are a foot long, the small divisions will be each 100th part of a foot, or a little more than the tenth of an inch, which it will be difficult to divide into ten parts. For the subdivisions this certainly is the case, and for which reason the small divisions are generally divided into two equal parts, and it is left to the operator to judge by the eye, as near as he can, the fifth part of that half, which, by a little practice, may very nearly be estimated; and I would also observe, when the number is large, the unit, in most practical cases, is of no great signification: thus, if the work we have in hand is to be made to the scale of 100 feet to one foot, the thousandth part of a foot, more or less, can, practically, be of little consequence.

Being thus prepared, I will now endeavor to show the use of Gunter, and beg the reader to remember, that, by the help of artificial numbers, called logarithms, we may perform the operation of multiplication and division by means of addition and subtraction; and by taking the half of any logarithm, we find another logarithm, which answers to the square root of the number expressed by the first logarithm, and divided into three parts, the cube root, &c.

Construction of Gunter's Line of Numbers.—Take any convenient scale (suppose one foot), and set the distance on your Gunter equal unity. Now, this is to be divided into ten parts to correspond to the logarithms of $\frac{1}{10}$ $\frac{2}{10}$ $\frac{3}{10}$, &c. Now the logarithm of $\frac{1}{10}$ is equal to 0; therefore the first division corresponds to the beginning of the scale (we have here nothing to do with the indices of the logarithms, which only denote whether the numbers be whole or fractional.) Now find the logarithm of $\frac{2}{10}$, which is 301; take this from your scale (supposing it divided into 1000 equal parts), and apply it to your Gunter, and you have the point marked 2. Again, the logarithm of $\frac{3}{10}$ is 477; take from your scale 477, and apply it to your Gunter, you have the point 3; and in this manner proceed for all the large divisions: and in the same manner lay down your small divisions to correspond to the logarithms of $\frac{1}{100}$ $\frac{2}{100}$ $\frac{3}{100}$, &c. (and if your scale will admit of it, you may find your subdivision in the same manner); thus you will have a scale expressing the logarithms of all numbers from ·001 to unity, if your whole scale is unity; or of ·01 to 10, if your scale is 10, or from ·1 to 100, if your scale is 100; and, lastly, if your scale is 1000, you will have the logarithms of all numbers from unity to 1000: and hence, adding any two or more of these divisions together is the same thing as multiplying the numbers they represent on the scale, and subtracting any one from

another is the same as dividing the numbers they represent on the scale, &c. Now, owing to the smallness of the divisions (even when your scale is a foot long), those small divisions, as you approach the end of your scale, cannot be divided into more than ten equal parts. To be seen distinctly, the general practice on Gunter's scale is, from the commencement of the scale to the point 2, to divide it into ten parts or small divisions: and again, each part to be subdivided into five parts for the subdivisions, from the 2 to the 5, each small division into two parts, and from 5 upwards cannot be divided into more than ten parts, to be distinct; hence, in the use of the scale, when the compasses do not fall exactly on any division, you must estimate as near as you can the subdivisions.

Note.—For those mechanics who would wish to construct a Gunter scale for themselves, I would recommend the inspection of some tables in Fergusson's Select Exercises, page 191 and following; and where they will also find full directions for the construction of the plane scale, sector, and Gunter's scale, at page 206 and following.

Use of Gunter's Line of Numbers.—Before giving some examples, I must premise, that in all the best scales the numbers from 1 to 10 are repeated twice, and form two equal and similar scales; and that when two or more figures are used, the compasses will often extend beyond the second scale; therefore there is part of a third similar scale, if not the whole, added, which generally extends to the number 2 or 3 only; but if your rule is long enough, the whole of a third scale is very useful, particularly for the extraction of the cube root.

To illustrate the application, I shall give the solution of the following examples:

To multiply 46 *by* 54.—Place one leg of your compasses at the beginning of your scale, and extend the other to 46, that is, to four of the large divisions, and six of the next small ones; then, with that extent, place one leg on 54, that is, at five of the large divisions, and four of the next following small ones, and the other will extend to two of the large divisions on the second scale, and four of the next following small ones, and a little more than the half of a division, which we will estimate as 80 subdivisions; that is, 2000 + 400 + 80 = 2480, which is within four units of the truth, and, as before observed, in general sufficiently exact for most practical purposes; but if the scale had been large enough to show the subdivisions, it is clear we should have had the true result.

To divide 2484 *by* 46.—Calling 2 in the second or right hand scale 2000, and each of the small divisions 100, set your compasses, with the distance 46 from the first scale, on the estimated point 2484, as near as you can guess; you will find the other leg, extended backwards to the first scale, will pitch on the point shown at 5 of the large divisions and 4 of the smaller ones, which is five tens, or 50, and four units, that is, 50 + 4 = 54, the true answer.

To extract the Square Root of 324.—Calling the large divisions of the first scale hundreds, extend the compasses to three of the large divisions, two of the small ones, and estimate four subdivisions, that is, 300 + 20 + 4 = 324; lay this distance down, for convenience, on a line drawn on paper, and divide it into two equal parts; take one of these parts in your compasses, and placing it at the scale, you will find it extend to 18 small divisions, that is, 18 units, the answer required.

I am afraid I have extended this article to too great a length and shall be thought prolix; but my aim has been to explain the use of the scale in a familiar manner to the workman; and though it may lay me under the censure of many versed in mathematical knowledge, it will, I am sure, be excused by those who look to the motives which induced me to be thus minute, which is, that *practical* mathematics may be extended as much as possible among the working classes. If this plan is persevered in, it will, I am confident, be of incalculable benefit to society in general. I am, sir, your obedient servant,

G. A. Seares.

Self-taught Philosophers.—We have heard and read much of self-made and self-taught men. The truth is, that every eminent man—especially among the literary, the scientific, the professional—has been a self-made man. Bacon and Locke, Milton and Newton, Burke and Mansfield, were as truly self-made and self-taught men as were Johnson and Franklin, Ferguson and Rittenhouse, Herschel and Fulton. The first enjoyed the advantages of a college directly, the latter indirectly: and all attained distinction by the same intellectual process. They severally availed themselves of all the instruments and sources of knowledge within their reach: and persevering industry, as a law of their existence, insured them victory

and honor. Rumford, Hutton, Davy, Sherman, Pope, Wythe, were as much debtors to the college as were Barrow, Edwards, Dwight, Fox, Scott, or Canning. The books, the science, the literary taste, the universal consideration attendant on superior mental endowments, which colleges had created, multiplied, diffused, and every where exhibited, led Franklin, as they have led thousands, to imitate, to master, to emulate, to rival, the excellence thus presented to their view and to their ambition. Had there been no colleges or seminaries of liberal learning—no literary or scientific enterprise or spirit abroad—Franklin might have been a Confucius or a Numa among barbarians, but he would never have been the first of philosophers and statesmen among the most enlightened nations of the earth.—[Lindley's Discourses.]

What is Education?—This may seem a very simple question, and very easily answered; but many who think so would really be very much at a loss to answer it correctly. Every man, in a free country, wants three sorts of education: one to fit him for his own particular trade or calling,—this is professional education; another to teach him his duties as a man and a citizen,—this is moral and political education; and a third, to fit him for his higher relations, as God's creature, designed for immortality,—this is religious education. Now, in point of fact, that is most useful to a man which tends most to his happiness; a thing so plain, that it seems foolish to state it. Yet people constantly take the word "useful" in another sense, and mean by it, not what tends most to a man's happiness, but what tends most to get money for him; and, therefore, they call professional education a very useful thing: but the time which is spent in general education, whether moral or religious, they are apt to grudge as thrown away, especially if it interferes with the other education, to which they confine the name of "useful;" that is, the education which enables a man to gain his livelihood. Yet we might all be excellent in our several trades and professions, and still be very ignorant, very miserable, and very wicked. We might do pretty well just while we were at work on our business; but no man is at work always. There is a time which we spend with our families; a time which we spend with our friends and neighbors; and a very important time which we spend with ourselves. If we know not how to pass these times well, we are very contemptible and worthless *men*, though we may be very excellent lawyers, surgeons, chemists, engineers, mechanics, laborers, or whatever else may be our particular employment. Now, what enables us to pass these times well, and our times of business also, is not our *professional* education, but our *general* one. It is the education which all need equally, namely—that which teaches a man, in the first place, his duty to God and his neighbor; which trains him to good principles and good temper; to think of others, and not only of himself. It is that education which teaches him, in the next place, his duties as a citizen—to obey the laws always, but to try to get them made as perfect as possible; to understand that a good and just government cannot consult the interests of one particular class or calling, in preference to another, but must see what is for the good of the whole; that every interest, and every order of men, must give and take; and that if each were to insist upon having every thing its own way, there would be nothing but the wildest confusion, or the merest tyranny. And because a great part of all that goes wrong in public or private life arises from ignorance and bad reasoning, all that teaches us, in the third place, to reason justly, and puts us on our guard against the common tricks of unfair writers and talkers, or the confusions of such as are puzzle-headed, is a most valuable part of a man's education, and one of which he will find the benefit whenever he has occasion to open his mouth to speak, or his ears to hear. And, finally, all that makes a man's mind more active, and the ideas which enter it nobler and more beautiful, is a great addition to his happiness whenever he is alone, and to the pleasure which others derive from his company when he is in society. Therefore it is most *useful* to learn to love and understand what is *beautiful*, whether in the works of God, or in those of man; whether in the flowers and fields, and rocks and woods, and rivers, and sea and sky; or in fine buildings, or fine pictures, or fine music; and in the noble thoughts and glorious images of poetry. This is the education which will make a man and a people good, and wise, and happy. Give this, and the ends of professional education can never be altogether lost—for good sense and good principle will insure a man's knowing his particular business; but knowledge of his business, on the other hand, will not insure *them*; and not only are sense and

goodness the rarest and most profitable qualities with which any man can enter upon life now, but they are articles of which there never can be a glut: no competition or over-production will lessen their value; but the more of them that we can succeed in manufacturing, so much the higher will be their price, because there will be more to understand and to love them.

Improvement in Social Condition.—The history of the United States of North America is, in some respects, one of the most instructive that we can turn to; because we are accurately acquainted with the origin of this social community, and are also enabled to trace its history in all its important facts, from the first establishment of the several colonies up to the present condition of the Union. Of all historical records none can be put in comparison with legislative enactments, as showing the condition of the people at any given period, and the degree of mental culture diffused among them. In the American States, even under their former colonial government, there were few men of any importance in the provinces who did not participate in some of the functions of government; and we may, therefore, consider the laws enacted at that period as indicative of the opinions held by the most influential classes.

We happen to have before us an old collection of Virginia laws, entitled, "A complete collection of the Laws of Virginia, at a Grand Assembly held at James City, 23d March, 1662;" a few extracts from which may not be uninteresting.

There appears to be in this volume only one law about education, which prescribes the founding of a college "for the advance of learning, education of youth, supply of the ministry, and promotion of piety." The law states how the money is to be raised; but as to its application nothing more is said, except that a piece of land is to be got, and, "with as much speed as may be convenient, housing is to be erected thereon for entertainment of students and scholars." The *housing* department seems to have been the uppermost thing in the legislature's thoughts; the providing of good teachers was a secondary consideration.

There are several enactments about "rewards for killing wolves," which at that time infested even the lower parts of Virginia. At the present day, owing to the increase of population, the wolf and other wild animals, though occasionally heard of, are but rarely seen even in the mountains, and seldom do any damage. The reward "for every wolf destroyed by pit, trap, or otherwise, is 200 pounds of tobacco."

Tobacco was the most common standard of value in Virginia at that time, as we see from this and numerous other instances, where fines, &c., are estimated at so many pounds of tobacco. Thus it is stated in enactment 35, that "the court shall not take cognizance of any cause under the value of 200 pounds of tobacco, or twenty shillings sterling, which a private justice may and is hereby authorized and empowered to hear and determine."

The following recipe for good order is contained in an enactment, entitled "Pillories to be erected at each Court:" "In every county the court shall cause to be set up a pillory, a pair of stocks, and a whipping-post, near the court-house, and a ducking-stool; and the court not causing the said pillory, whipping-post, stocks, and ducking-stool, to be erected, shall be fined 5000 pounds of tobacco to the use of the public."

In those days the following provision was made for extending the elective franchise, which appears founded on a rational principle: "Every county that will lay out 100 acres of land, and people it with 600 tytheable (taxable) persons, that place shall enjoy the like privilege of sending a burgess." The burgesses, together with their attendants, were free from arrest, from the time of election till ten days after dissolution of the assembly; this privilege, however, was somewhat modified by several clauses. Every burgess was allowed, during the sitting of the assembly, "150 pounds of tobacco, and cask, per day, besides the necessary charge of going to the assembly and returning." This practice of paying legislators, which, in America, originated under the Colonial system, is still continued in the United States. It did not entirely cease in England until the reign of Charles II. Andrew Marvel, one of the burgesses of Hull, was the last member of the House of Commons who appears to have accepted the wages which all were entitled to receive.

Among commercial restrictions we find an enactment prohibiting the planting of tobacco after the 10th of July, which was done for "the improvement of our only commodity, tobacco, which can no ways be effected but by lessening the quantity and amending the quality." That the former effect might pos-

sibly be produced by the enactment, without securing the latter, seems pretty certain. Another object that the government had in view was to compel the people to become silk-growers against their will. "Be it, therefore, enacted," says the legislature, "that every proprietor of land within the colony of Virginia shall, for every hundred acres of land holden in fee, plant upon the said land ten mulberry-trees at twelve foot distance from each other, and secure them by weeding and a sufficient fence from cattle and horses." Tobacco fines, as usual, were enacted in case the planting and weeding were not duly performed; and further, "there shall be allowed in the public levy to any one for every pound of wound silk he shall make, fifty pounds of tobacco, to be raised in the public levy, and paid in the county or counties where they dwell that make it." This act was passed in 1662, and probably continued in force for a long time; but Virginia did not, therefore, become a silk-growing country, nor has it yet, though many parts are well adapted to raise this commodity. People, we presume, have hitherto found other things more profitable than silk.

The following enactment has a most barbarous character about it, not unmixed with something extremely ludicrous as to the idea of the legislature trying to prevent women from talking: "Whereas many babbling women slander and scandalize their neighbors, for which their poor husbands are often involved in chargeable and vexatious suits, and cast in great damages: Be it therefore enacted, that in actions of slander, occasioned by the wife, after judgment passed for the damages, the woman shall be punished by ducking; and if the slander be so enormous as to be adjudged at greater damages than 500 pounds of tobacco, then the woman to suffer a ducking for each 500 pounds of tobacco adjudged against the husband, if he refuse to pay the tobacco."

This old statute book of Virginia is full of enactments such as we have quoted; some exceedingly mischievous, and others very ludicrous. It would, however, be unfair to say that there are not also some good regulations in it. Were a history of our own or any other country to be written, founded on the legislative enactments, and illustrated, whenever it was possible, by individual cases on record, we should then begin to have some idea of what history is. Instead of the splendors or the follies of a few who occupy the attention of the historian, we should be able to form a more complete picture of the condition of the whole community, and a more exact estimate of the progress which has been made in social knowledge.

Salt.—There are many countries on the habitable globe where salt has never yet been found, and whose commercial facilities being extremely limited, the inhabitants can only occasionally indulge themselves with it as a luxury. This is particularly the case in the interior of Africa. "It would," says Mungo Park, "appear strange to an European to see a child suck a piece of rock-salt as if it were sugar. This, however, I have frequently seen; although the poorer class of inhabitants are so very rarely indulged with this precious article, that to say that a man eats salt with his provisions is the same as saying he is a rich man. I have suffered great inconvenience myself from the scarcity of this article. The long use of vegetable food creates so painful a longing for salt, that no words can sufficiently describe it."—[Park's Travels into the Interior of Africa.]

New Printing Machine.—A new printing machine has been invented in England, by a practical printer, which is highly spoken of in one of the late Liverpool papers. We subjoin the editor's notice of it:

Mr. J. Kitchen, of the Newcastle Journal, has invented a printing press, which bids fair to revolutionize this department of the arts. It bears no analogy, even in appearance, to any machine for the purpose hitherto known. The *form* can be fixed in its place in a single moment, and will, when adjusted, remain stationary until the work is finished. Complete facilities are given for regulating the power, and the quantity of ink, and for overlaying and obtaining register. The same machine will be equally applicable for the smallest job or the largest sheet; it will be perfectly under control, and only require one man during the process of printing; or where great speed is required, and the work is heavy, a man and a *fly-boy*: whilst it can be sold for the same price as the common press. Mr. Kitchen is now engaged in the application to his invention of a clock-work movement, so that a machine may keep a register of its own work, and thus act as a check upon waste of paper and idleness in the absence of the employer or overseer.

The inventor, when practically engaged in the business several years ago, was struck

with the anomaly, that whilst printing was the medium of extending the boundary of knowledge, and communicating to the public every experiment in science or mechanics, "The Press" itself has remained precisely the same, in principle, to that employment when the art was first introduced into this kingdom. Lord Stanhope made the machine of metal instead of wood, and conferred upon it greater power, with several minor alterations. This gave an impulse to improvements, and presses are now made greatly superior to Lord Stanhope's, but none of them deserve the name of new inventions. The slow lumbering process of frisket and tympan; the table with alternate motion, and the dirty and inconvenient appendage of an inking table, detached from the press, are still scrupulously preserved, all of which were employed for the same purpose in the time of Caxton.

Mr. Kitchen's first effort was directed to the construction of a press on the old principle just described, with the advantages of a self-inking apparatus, and obtaining increased pressure by the application of hydraulic power. In the first object he succeeded; but after a long series of experiments, found that the requisite *speed* could not be obtained by hydraulics, and turned his attention to some other plan.

Since these experiments were commenced, the splendid *foreign* invention of the steam press has been introduced into this country; but it is at once so complicated, cumbersome and costly, that it can only be purchased by large capitalists, and employed in extensive offices. The same remarks will apply to the several modifications of it, to work without steam.

A few Remarks on the Relation which subsists between a Machine and its Model. By Edward Sang, Teacher of Mathematics, Edinburgh.

At first sight, a well constructed model presents a perfect representation of the disposition and proportion of the parts of a machine, and of their mode of action.

Misled by the alluring appearance, one is apt, without entering minutely into the inquiry, also to suppose that the performance of a model is, in all cases, commensurate with that of the machine which it is formed to represent. Ignorant of the inaccuracy of such an idea, too many of our ablest mechanicians and best workmen waste their time and abilities on contrivances, which, though they perform well on the small scale, must, from their very nature, fail when enlarged. Were such people acquainted with the mode of computing the effects, or had they a knowledge of natural philosophy, sufficient to enable them to understand the basis on which such calculations are founded, we should see fewer crude and impracticable schemes prematurely thrust upon the attention of the public. This knowledge, however, they are too apt to regard as unimportant, or as difficult of attainment. They are startled by the absurd distinction which has been drawn between theory and practice, as if theory were other than a digest of the results of experience; or, if they overcome this prejudice, and resolve to dive into the arcana of philosophy, they are bewildered among names and signs, having begun the subject at the wrong end. That the attainment of such knowledge is attended with difficulty is certain, but it is with such difficulty only as can be overcome by properly directed application. It would be, indeed, preparing disappointment to buoy them up with the idea, that knowledge, even of the most trivial importance, can be acquired without labor. Yet it may not be altogether unuseful, for the sake both of those who are already, and of those who are not, acquainted with these principles, to point out the more prominent causes, on account of which the performance of no model can, on any occasion, be considered as representative of that of the machine. Such a notice will have the effect of directing the attention, at least, to this important subject. In the present state of the arts, the expense of constructing a full-sized instrument is, in almost every instance, beyond what its projector would feel inclined, or even be able, to incur. The formation of a model is thus universally resorted to, as a prelude to the attempt on the large scale. An inquiry, then, into the relation which a model bears to the perfect instrument, can hardly fail to carry along with it the advantage of forming a tolerable guide, in estimating the real benefit which a contrivance is likely to confer upon society.

In the following paper I propose to examine the effect of a change of scale on the strength and on the friction of machines, and, at the same time, to point out that adherence to the strictest principles which is apparent in all the works of nature, and of which I mean to avail myself in fortifying my argument.

Previous, however, to entering on the subject-proper, it must be remarked that, when we enlarge the scale according to which any

instrument is constructed, its surface and its bulk are enlarged in much higher ratios. If, for example, the linear dimensions of an instrument be all doubled, its surface will be increased four, and its solidity eight-fold. Were the linear dimensions increased ten times, the superfices would be enlarged one hundred, and the solidity one thousand times. On these facts, the most important which geometry presents, my after-remarks are mostly to be founded.

All machines consist of moveable parts, sliding or turning on others, which are bound together by bands, or supported by props. To the frame work I shall first direct my attention.

In the case of a simple prop, destined to sustain the mere weight of some part of the machine, the strength is estimated at so many hundred weights per square inch of cross section. Suppose that, in the model, the strength of the prop is sufficient for double the load put on it, and let us examine the effect of an enlargement, ten-fold, of the scale according to which the instrument is constructed. By such an enlargement, the strength of the prop would be augmented 100 times; it would be able to bear 200 loads such as that of the model, but then the weight to be put on it would be 1000 times that of the small machine, so that the prop in the large machine would be able to bear only the fifth part of the load to be put on it. The machine, then, would fall to pieces by its own weight.

Here we have one example of the erroneous manner in which a model represents the performance of a large instrument. The supports of small objects ought clearly to be smaller in proportion than the supports of large ones. Architects, to be sure, are accustomed to enlarge and to reduce in proportion; but nature, whose structures possess infinitely more symmetry, beauty, and variety, than those of which art can boast, is content to change her proportions at each change of size. Let us conceive an animal having the proportions of an elephant and only the size of a mouse; not only would the limbs of such an animal be too strong for it, they would also be so unwieldy that it would have no chance among the more nimble and better proportioned creatures of that size. Reverse the process, and enlarge the mouse to the size of an elephant, and its limbs, totally unable to sustain the weight of its immense body, would scarcely have strength to disturb its position even when recumbent.

The very same remarks apply to that case in which the weight, instead of compressing, distends the support. The chains of Trinity Pier are computed to be able to bear nine times the load put on them. But if a similar structure were formed of ten times the linear dimensions, the strength of the new chain would be one hundred times the strength of that at Trinity, while the load put upon it would be one thousand times greater; so that the new structure would possess only nine-tenths of the strength necessary to support itself. Of how little importance, then, in bridge building, whether a model constructed on a scale of perhaps one to a hundred support its own weight! Yet, on such grounds, a proposition for throwing a bridge of two arches across the Forth, at Queensferry, was founded. Putting out of view the road-way and passengers altogether, the weight of the chain alone would have torn it to pieces. The larger species of spiders spin threads much thicker, in comparison with the thickness of their own bodies, than those spun by the smaller ones. And, as if sensible that the whole energies of their systems would be expended in the frequent reproduction of such massy webs, they choose the most secluded spots; while the smaller species, dreading no inconvenience from a frequent renewal of theirs, stretch them from branch to branch, and often from tree to tree. I have often been astonished at the prodigious lengths of these filaments, and have mused on the immense improvement which must take place in science, and in strength of materials too, ere we could, individually, undertake works of such comparative magnitude.

When a beam gives support laterally, its strength is proportioned to its breadth, and to the square of its depth conjointly. If, then, such a beam were enlarged ten times in each of its linear dimensions, its ability to sustain a weight placed at its extremity would, on account of the increased distance from the point of insertion, be only one hundred times augmented, but the load to be put upon it would be one thousand times greater; and thus, although the parts of the model be quite strong enough, we cannot thence conclude that those of the enlarged machine will be so.

It may thus be stated as a general principle, that, in similar machines, the strengths of the parts vary as the square, while the weights laid on them vary as the cube of the corresponding linear dimension.

This fact cannot be too firmly fixed in the minds of machine makers; it ought to be taken

into consideration even on the smallest change of scale, as it will always conduce either to the sufficiency or to the economy of a structure. To enlarge or diminish the parts of a machine all in the same proportion, is to commit a deliberate blunder. Let us compare the wing of an insect with that of a bird: enlarge a midge till its whole weight be equal to that of the sea-eagle, and, great as that enlargement must be, its wing will scarcely have attained the thickness of writing paper; the falcon would feel rather awkward with wings of such tenuity. The wings of a bird, even when idle, form a conspicuous part of the whole animal; but there are insects which unfold, from beneath two scarcely perceived covers, wings many times more extensive than the whole surface of their bodies.

The larger animals are never supported laterally; their limbs are always in a position nearly vertical: as we descend in the scale of size the lateral support becomes more frequent, till we find whole tribes of insects resting on limbs laid almost horizontally. The slightest consideration will convince any one that lateral or horizontal limbs would be quite inadequate to support the weight of the larger animals. Conceive a spider to increase till his body weighed as much as that of a man, and then fancy one of us exhibiting feats of dexterity with such locomotive instruments as the spider would then possess!

The objects which I have hitherto compared have been remote, that the comparisons might be the more striking; but the same principles may be exhibited by the contrast of species the most nearly allied, or of individuals even of the same species. The larger species of spiders, for instance, rarely have their legs so much extended as the smaller ones; or, to take an example from the larger animals, the form of the Shetland poney is very different from that of the London dray horse.

How interesting it is to compare the different animals, and to trace the gradual change of form which accompanies each increase of size! In the smaller animals, the strength is, as it were, redundant, and there is room for the display of the most elaborate ornament. How complex or how beautiful are the myriads of insects which float in the air, or which cluster on the foliage! Gradually the larger of these become more simple in their structure, their ornaments less profuse. The structure of the birds is simpler and more uniform, that of the quadrupeds still more so. As we approach the larger quadrupeds, ornament, and then elegance, disappear. This is the law in the works of nature, and this ought to be the law among the works of art.

Among one class of animals, indeed, it may be said that this law is reversed. We have by no means a general classification of the fishes; but, among those with which we are acquainted, we do not perceive such a prodigious change of form. Here, however, the animal has not to support its own weight; and whatever increase may take place in the size of the animal, a like increase takes place in the buoyancy of the fluid in which it swims. Many of the smaller aquatic animals exhibit the utmost simplicity of structure; but we know too little of the nature of their functions to draw any useful conclusions from this fact.

Excess in the Pursuit of Knowledge.—The chief end why we are to get knowledge here is to make use of it for the benefit of ourselves and others in this world; but, if by gaining it we destroy our health, we labor for a thing that will be useless in our hands; and if by harassing our bodies (though with a design to render ourselves more useful), we deprive ourselves of the abilities and opportunities of doing that good we might have done with a meaner talent—which God thought sufficient for us, by having denied us the strength to improve it to that pitch which men of stronger constitutions can attain to, —we rob God of so much service, and our neighbor of all that help, which, in a state of health, with moderate knowledge, we might have been able to perform. He that sinks his vessel by overloading it, though it be with gold and silver and precious stones, will give his owner but an ill account of his voyage.—[Locke.]

Water Color for Rooms.—Take a quantity of potatoes and boil them; then bruise and pour boiling water upon them until a pretty thick mixture is obtained, which is to be passed through a sieve. With boiling water then make a thick mixture of whitening, and put it to the potato mixture. To give color, if white is not wanted, add different colored ochres, lampblack, &c. according to circumstances. This paint dries quickly, is very durable, has a good appearance to the eye, and is moreover very cheap.—[London Paper.]

Injury of Turpentine to Paint. By Robt. R. Harden. [From the Southern Planter.]

We use paint on our wooden buildings with two objects: first, ornament—second, durability. Was oil used by itself, without any coloring matter, the wood would be made more durable than it is with paint; but as ornament is a considerable part of the objects of painting, and as the addition of paint to the oil, when properly prepared, does not very materially injure the preservative qualities of the oil, the ornamental effect of the coloring more than counterbalances the injury it does. Paint, when properly prepared, therefore, while it is highly ornamental to wooden buildings, so materially contributes towards their durability, that there is economy in using it. But as it is generally prepared, (I may say always,) the ornamental effect of it on the outside of buildings is made only temporary, and its preservative qualities wholly destroyed. It is only necessary to look at our quickly decaying wooden buildings, with the paint washed off more or less in different places, according as it is exposed to the sun and rain, to be satisfied that the expense of painting has added very little towards preserving the building; and whether a building looks better without paint, or with paint nearly all washed off, with here and there a little remaining to show that it once was painted, taste must determine. If what I have stated be a fact, that paint, as mostly prepared, is of little value, it will be well to look into the cause of it, that the evil may be remedied; and if I give the correct cause, happily the evil is removed without expense or trouble; or rather, it is cheaper to paint well than in this defective manner. We have only to leave out the spirits of turpentine, and we will have good paint. Ask the painter why he adds it to the paint, and he will tell you to make it dry quick. This is just the same as saying, to destroy the oil, which renders the paint useless. Now let us reason upon it, and see if this is correct. If we pour oil on wood it soaks into it, and after it is all soaked up, if we apply more oil, it will strike still deeper and soak up more; when it has penetrated sufficiently deep into the wood as to prevent moisture from rain, &c. penetrating as deep as itself, the wood is rendered very lasting. This would be the case if a building was simply covered with two coats of oil without paint. If we give it only one coat of oil, with a sufficient quantity of paint to give it color, the wood would so quickly soak up the oil that the paint would be left a dry powder on the building, that would be easily rubbed or washed off. If we give it first a coat of oil with a little paint added to it, the oil soaks into the pores; another coat of oil with the proper quantity of paint, while the pores are filled with the recently put on or first coat, remains sufficiently long before the oil is soaked up by the pores for a part of it to dry with the paint, which forms a covering of paint. This is the advantage of giving two coats of paint; if the first coat was oil only, it would be better. When a house is thus painted, all the injury done by the paint is the oil which it retains and prevents from soaking into the wood; and this is in part, perhaps wholly, counterbalanced in forming a firm external covering, which tends to exclude moisture; thus painted, a building is preserved and ornamented. Now what will be the effect of adding spirits of turpentine to the oil? We know of nothing better calculated to destroy our intentions in the use both of the oil and paint than this addition of turpentine. Every housekeeper knows that if oil is on the floor, spirits of turpentine is the application to remove it. Every wash-woman knows that if oil is on her clothes, turpentine is the application to remove it; and how does it remove it when the oil and turpentine are added together? A chemical union takes place and the qualities of both are destroyed, and although either the oil or turpentine by themselves when applied on wood would add to its durabitity, yet when added together the original quality of both are destroyed, and the application is useless, just as an acid and alkali, when mixed together, destroy the qualities of each other and the effect of neither remains. Now, when a building is painted with two coats of paint to which spirits of turpentine is added, instead of the first covering of oil (which has very little paint) being soaked up, and the second covering, as the pores are already fed, soaking up the oil so slow that a part of the oil may dry in the paint, thus making a firm coat of paint on the surface, which will exclude moisture and prevent the evaporation of the oil, thus making the wood almost as lasting as time, and the color to remain as long as the wood lasts, what will be the effect of this addition of turpentine? The oil is decomposed, and instead of soaking into the wood and slowly drying in the paint to give a firm covering, it is quickly evaporated by the sun, the paint is left a useless powder on the wood; where it is not sheltered from the rain, it is soon

washed away; and in places where it only gets wet without being washed off, as the qualities of the oil are destroyed, it retains moisture and hastens decay. We have only to go to a house which was painted white, and examine the somewhat sheltered spots where they get wet by showers, tho' the rain does not beat upon them so as to wash off the paint, and scratch off the paint, and we will find the surface in a state of decay, from the paint not excluding moisture, but retaining it. When pine wood is painted, it should more especially have only oil and paint without the spirits of turpentine, as there is in the wood turpentine sufficient to injure the oil. If we examine the shingles or weather-boarding of a house, we will find wherever there is a knot or *fat place*, there the oil is decomposed by the turpentine in the wood, and the paint destroyed, even where no spirits of turpentine was added to the paint.

The oldest paintings we have appear as warm and glowing as when first executed, while the paintings of the first masters of modern times are injured, mostly as I think by the free use of turpentine. The fine paintings even of Sir Joshua Reynolds are losing their beauty. By some it is supposed that the paints used now are not as good as they were in former days. 'Tis not the fault of the materials, but the preparation. Oil, for instance, and white lead, are as good now as they ever were, and were they used without turpentine or any thing else, as the painters say to make them dry, (or as we say, to decompose the oil and destroy it,) would last as long and be as good as they ever were. If we calculate the annual amount of money used in the purchase of turpentine, and to this add the amount of loss from the injury it does, we will find it an enormous expense.

Perhaps nine out of ten houses that take fire from sparks falling on the roof, do so from this mossy growth, which never is produced on wood that is oiled; were shingles dipped in hot oil before putting them up, it would be a preventive from fire from sparks. A few days ago, during almost a calm, at mid day, when only a few coals were in the fire place, my house roof was discovered to be on fire. As there was no ladder nor no way of getting at the fire, it seemed as though the house would burn down. A very strong man, however, by getting in the window of a house not far off, was able to deaden the fire a little by throwing water with great strength; some drops would reach the fire: thus some little time was given for reflection. A man of great muscular strength with a small hatchet commenced cutting through the ceiling and sheeting. The fire began to blaze, the wind began to rise, all hope of extinguishing the fire was gone: he had however cut a hole through, and was able to tear off the boards and put out the fire. These shingles, upon examination, were found sound, but they were covered with this mossy growth. A very small spark must have set it on fire, for upon trial it was found almost as quick to take as gunpowder. Had these shingles been dipped in oil before they were put on the house, I would have been safe from such an accident, not only now, but for many years to come.

Starvation Farm, Feb. 12, 1833.

Foul Casks.—Foul pails, tubs, or casks, intended for butter or any other purpose, may be cleansed by putting in some bran, indian meal, or flour, and filling up with water; a fermentation will take place which will perfectly cleanse the vessel. The liquid is the better for hogs after undergoing fermentation; consequently there is no expense attending the process.

Hancock's Steam Carriage.—The following letter of Mr. Hancock, showing the performances of his Steam Omnibus, is taken from Bell's Weekly Messenger, to the Editor of which it is addressed:

Stratford, May 3, 1833.

Sir,—More than six years have elapsed since I began my experiments on Steam Locomotion, and I have followed them with an ardor that did not admit of any diversion from the object which I kept steadily in view.

During the past fortnight I have exhibited daily on the Paddington road a Steam Omnibus, the result of my experience; and having hitherto steered clear both of extravagant anticipations and exaggerated statements, I should be sorry now if any such should find their way into the public prints; and in order to prevent this, as far as I am able, I beg to hand you an account of each day's performance, if you think it is of sufficient interest to occupy a place in your columns.

Having furnished these data, and given to the public opportunities of witnessing the performance of this carriage in the streets and on the most crowded and hilly road in the immediate neighborhood of the metropolis, I trust that I have demonstrated to the most sceptical the practicability of applying

steam economically to the purposes of inland transport.

	Miles.	Total time.	Delays.	Travelling time.
		min.	min.	min.
April 22—From City-road to Paddington, thence to London Wall, and back to City-road - - - - - -	10	68	18	50
23—City-road to Paddington, and back	8½	71	9	62
24—Do. do. - - - -		64	11½	53
25—From City-road to Paddington, and back to the middle of Pentonville-hill, where the pressure of the steam broke the piston of the off Engine - -				
26—Put in new piston, double the strength of the former. From City-road to Paddington, and back - -	8½	49	5	44
27—Do. do. - - - - - -		50	5½	44½
29—Do. do. - - - - - -		51	5½	45½
30—Do. do. - - - - - -		51	6½	45
May 1—From City-road to Paddington, thence round Finsbury-square, and back to City-road - - - - -	10	78	15	63
2—Do. do. - - - - - -		67	9	58
3—Do. do. - - - - - -		79	18	61

The average quantity of coke used has been three bushels each journey. I am, Sir, your obedient servant, W. Hancock.

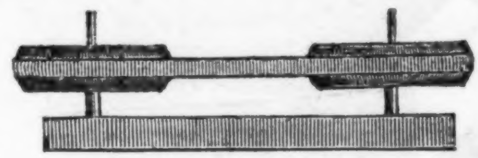
Public Instruction in France.—The minister of public instruction in France has addressed circulars to the rectors, &c. for the establishment of schools for primary teachers. Within two years, this important class of schools,—in which we are so deficient in the United States,—has increased in number from 30 to 47. What might one such school accomplish in each of our new States.

Much interest is shown in France, especially in certain departments, in the establishment of schools. The whole number of schools in the kingdom, in 1832, was 4,055, with 231,365 scholars: a greater number of scholars than in 1829. Schools have been established, where there were none in 1829, in 2,741 communes, (or townships.) The schools of mutual instruction have increased 536, and the normal schools 34.

Schools and courses of instruction for the adults and laborers of Paris,—founded by individuals and societies,—are encouraged by the minister of public instruction, unless they have a political bearing.—[New-York Advocate.]

Of Wheel Work.—In treating of the simple mechanical power, called the wheel and axle, (see The Artisan, vol. i. p. 86), we stated that motion was communicated from one wheel to another, either by belts and straps passing over them, or by teeth cut in the circumference of each, and working in one another. We shall now enter a little more fully into the subject and endeavor to explain some of the most useful principles upon which this branch of practical mechanics depends, and also to point out the various methods of applying this mechanical power in the motion of different kinds of machinery.

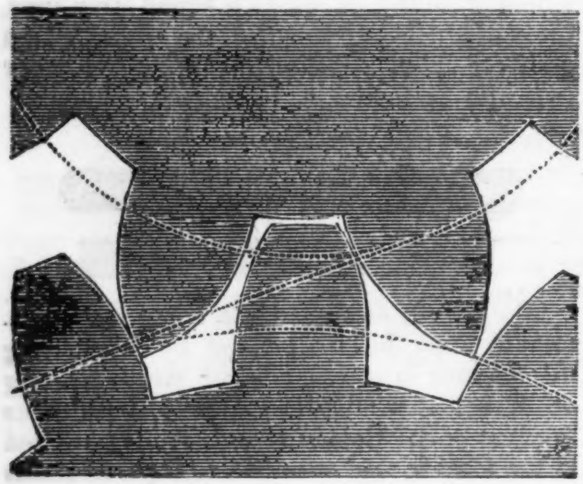
Where a broad strap runs on a wheel, it is usually confined to its situation, not by causing the margin of the wheel to project, but, on the contrary, by making the middle prominent, as represented by the following wheel or pulley, on which a broad strap runs, the surface being convex; the wheel which drives it is of a similar form but its upper part only is shown in the figure.



The reason of the middle being made prominent may be understood by examining the manner in which a tight strap, running on a cone, would tend to run towards its thickest part. Sometimes also pins are fixed in the wheels, and admitted into perforations in the straps; a mode only practicable where the motion is slow and steady. A smooth motion may also be obtained, with considerable force, by forming the surfaces of the wheels into brushes of hair. More commonly, however, the circumferences of the contiguous wheels are formed into teeth, impelling each other, as with the extremities of so many levers, either exactly or nearly in the common direction of the circumferences; and sometimes an endless screw is substituted for one of the wheels.

In forming the teeth of wheels, it is of consequence to determine the curvature which will produce an equable communication of motion with the least possible friction. For the equable communication of motion, two methods have been recommended; one, that the lower part of the face of each tooth should be a straight line in the direction of the radius, and the upper, a portion of an epicycloid; that is, of a curve described by a point of a circle rolling on the wheel, of which the diameter must be half that of the opposite wheel; and in this case it is demonstrable, that the plane surface of each tooth will act on the curved surface of the opposite tooth, so as to produce an equable angular motion in both wheels: the other method is, to form all the

surfaces into portions of the involutes of circles, or the curves described by the point of a thread which has been wound round the wheel while it is uncoiled; and this method appears to answer the purpose, in an easier and simpler manner than the former. The following figure represents the teeth, &c. of two wheels, formed into involutes of circles, described by uncoiling a thread from the dotted circles; the point of contact of the teeth being always in the straight line, which ouches both circles.



It may be experimentally demonstrated, that an equable motion is produced by the action of these curves on each other; if we cut two boards into forms, terminated by them, divide the surfaces by lines into equal or proportional angular portions, and fix them on any two centres, we shall find that, as they revolve, whatever parts of the surfaces may be in contact, the corresponding lines will always meet each other.

Both of these methods may be derived from the general principle, that the teeth of the one wheel must be of such a form, that their outline may be described by the revolution of a curve upon a given circle, while the outline of the teeth of the other wheel is described by the same curve revolving within the circle. It has been supposed by some of the best officers, that the epicycloidal tooth has also the advantage of completely avoiding friction; this is, however, by no means true, and it is even impracticable to invent any form for the teeth of a wheel which will enable them to act on other teeth without friction. In order to diminish it as much as possible, the teeth must be as small and as numerous as is consistent with strength and durability; for the effect of friction always increases with the distance of the point of contact from the line joining the centres of the wheels. In calculating the quantity of the friction, the velocity with which the parts slide over each other has generally been taken for its measure; this is a slight inaccuracy of conception, for the actual resistance is not at all increased by increasing the relative velocity; but the effect of that resistance, in retarding the motion of the wheels, may be shown, from the general laws of mechanics, to be proportional to the relative velocity thus ascertained.

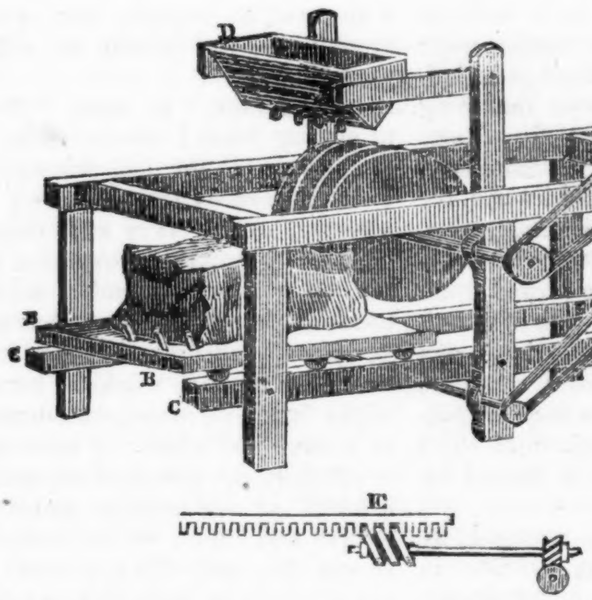
When it is possible to make one wheel act on teeth fixed in the concave surface of another, the friction may be thus diminished in the proportion of the difference of the diameters to their sum.

Hamilton's Patent Sawing and Boring Machine.—We have experienced much gratification in examining this useful labor-saving machine; and we are perfectly satisfied that it is destined to be of great public utility in cheapening the price of those articles which are in use by all classes of society, and will at the same time be a source of great profit to the ingenious mechanic who has invented it. We have no means of ascertaining the precise amount of labor and expense which this machine will save, but we venture to hazard the opinion that a man and two apprentices will accomplish more in *twelve* hours than *forty* experienced journeymen can accomplish at the same work during the same period of time. It is withal one of those inventions which require no extraneous aid to bring it into immediate usefulness. The proprietor has commenced working it daily, and in a ware-room adjoining the machine he offers for sale its produce at from thirty to fifty per cent. less than the market price. This simple fact and the certainty that the work is in all its parts more perfect than that manufactured by hand, has produced a demand more than equal to the supply.

The machine is admirably well adapted to any sort of sawing that is usually done by hand or cross-cut sawing. Tenons, mitre-joints, &c. are cut with the greatest precision. In all sorts of pannel work and small framing it will be very useful. It is peculiarly adapted to sawing regular and eccentric circles, such as felloes for wheels, chair tops, seats, legs, and backs, and circular blocks for brushes; and it saws chair tops and seats with great accuracy on a bevel.

Each segment of a wheel is cut its proper length and proper inclination for the joint—the holes are bored for the dowels and spokes, and the hubs are bored on a principle entirely new, making every spoke stand with the greatest exactness from the centre to the extreme of the circle. The machine is perfectly simple in its construction, not liable to get out of repair, and easy to manage and understand. A few hours' acquaintance with it will enable any one, whether mechanic or otherwise, to operate on it as well as the inventor. It is only six feet square, and is propelled by a steam engine of two-horse power.

A part of the principle of the same machine is applied to a small portable frame, and used for sawing wood for the fire with a rapidity really astonishing.—[Courier & Enquirer.]



Specification of a patent for an improvement in the method of sawing Marble, and other stone, and cutting or working mouldings, or groovings, thereon, and polishing the same. Granted to Isaac D. Kirk, city of Philadelphia. [From the Journal of the Franklin Institute.]

References—A, The saws, or the moulding cylinder of soft cast iron; B, Carriage to support and carry forward the marble, or stone; C C, Rails on which the carriage travels; D, Hopper for sand and water; E, Apparatus for advancing the carriage.

To all to whom these presents shall come, be it known, that I, Isaac D. Kirk, of the city of Philadelphia, and state of Pennsylvania, have invented a new and useful improvement in the method of sawing marble and other stone, and cutting, or working, mouldings, or groovings, thereon, and polishing the same; the sawing being performed by means of an improved revolving, circular, metallic plate, smooth, or without teeth, upon the face, or edge, operating by friction with sand and water upon the material to be cut; and the moulding, or grooving, and polishing, being effected by means of the improved revolving moulding and polishing cylinder, or wheel, operating in cutting mouldings by friction with sand and water upon the surface to be wrought; and in polishing by friction, in like manner, with putty, buff, pumice-stone, or some other suitable material; viz. one or more circular metallic plates, smooth or not serrated upon the face, or cutting edge, (copper, or soft iron, are deemed preferable,) are securely fixed, vertically, upon a horizontal shaft, or spindle, of iron, of any required dimensions, passing through the centre of the plate, or plates, and supported at each end by a proper frame of wood, or of cast iron, upon which the shaft works. On one end of the shaft is a cog wheel to connect it to the moving power.

Where two or more plates are used on the same shaft, they are secured at the proper distance from, and parallel to, each other, by circular metallic bands of a thickness adapted to the intended thickness of the slab, or slabs, to be cut; which bands are fitted upon and around the shaft between the plates, or saws. Under the shaft, at the distance

of a little more than the radius of the plates, or saws, is a carriage on friction rollers, or wheels, resting on a permanent railway, to support and carry forward the stone, or marble, to the plates, or saws; it is moved either by a rack and pinion, or by weights and pulleys. Over the saws is fixed a hopper, filled with sand and water, which is carried by a conductor leading from an aperture in its bottom, to the saws, at the point of their contact with the stone or marble. The plates, or saws, may be made of any required dimensions, and must be wrought to a uniform thickness throughout, with the cutting edge smooth, or not serrated, and either rounded, bevelled or flat. The improved moulding and polishing cylinder, or wheel, is of any metal, (cast iron is preferable for moulding, and some of the softer metals, and wood, for polishing,) and of any requisite dimensions, having the converse of the intended moulding, or grooving, either cast or turned upon its surface, or periphery, by means of which any series of mouldings, or groovings, can be wrought on a surface of marble, or stone, at one operation, and in like manner be polished. It is fixed upon a horizontal shaft passing through its axis, which is turned by a cog wheel connecting it to the power, and operates on the material to be wrought, by revolving vertically against its surface in contact with sand and water in cutting mouldings, and in contact with pumice-stone, buff, putty, or some other suitable material in polishing. A cylinder, having a regular smooth surface, is used in like manner for flatting, and for polishing a plain surface. The marble, or stone, is carried forward, and under the moulding and polishing cylinders, by a mechanical arrangement similar to that before described.

The polishing cylinder is similar in form to the above, and used in like manner with polishing powder, as putty, buff, &c. instead of sand, and is made of wood, or some of the softer metals.

The improvement claimed by said Isaac D. Kirk consists in the sawing of marble, or other stone, by means of a revolving, circular, metallic plate, smooth, or not serrated, on the face, or edge, and applied with sand and water, as is done with the straight saw; and also in making or forming upon the surface, or periphery, of a metallic or wooden cylinder, or wheel, the converse of the intended moulding, or grooving; by means of which, a series of mouldings, or grooves, can be wrought on a surface of marble, or stone, at one operation, with sand and water; and in like manner, polished with putty, buff, pumice-stone, or other polishing material.

Isaac D. Kirk.

Remarks by the Editor.—From the information which we have received relating to the above described machine, its invention appears likely to mark an important epoch in the art of working marble; this information has been derived from a gentleman of much intelligence, residing in Philadelphia, who relates only what he himself witnessed, as regards the operation of the machinery, and which we will give in his own words.

"I embrace," he says, "this opportunity of stating what I have seen of the practical operation of the experimental machinery erected here by the patentee; which, I will observe, was of very rude construction, and capable of great improvement in its application on a more extended scale. The saw used in these experiments was a circular copper plate of thirty-one inches in diameter, attached to a shaft working horizontally on a slight frame of wood, and turned by means of a band and whirl. I have seen this saw, worked by the power of *one man*, cut through a block of our hardest marble, one foot in length and depth, or one foot square, in thirty minutes; and with increased power I doubt not it might be done in much less time.

"I also, at the same time, saw the moulding wheel, of cast iron, work out mouldings on a slab of marble one foot in length, in one minute and a half, and have no doubt that the same could be done more rapidly with machinery less rudely constructed.

"The marble is left by the saw, as well as by the moulding wheel, or cylinder, in a state fit for polishing, without any preparatory chiselling, or rubbing down with sand; and the polishing is performed in the same manner as the moulding, and with equal or greater rapidity."

We are informed that in the sawing of large blocks of marble in the ordinary way, from six to eight square feet is accounted a good day's work; but that in the cutting of small blocks, a workman can rarely cut more than two or three feet. From the experiment above recited, it appears fair to conclude that ten times as much can be effected by Kirk's machinery, when operating on small blocks, and probably upon any which are not too large for the circular saw. This also, it may be observed, is not limited in its diameter by the same cause which limits

those made of a single plate for sawing timber, namely, the expansion by heat, which causes the saw to buckle, an effect which will be prevented in the cutting of stone by the saw being kept constantly wet. The cost of a saw will be saved in the work performed by it in one or two days.

The letter from which we have quoted does not mention the width of the mouldings wrought by the revolving moulding wheel, but it appears likely that the saving of time in this usually slow operation will much exceed that effected in sawing.

We perceive by the records of the patent office, that Mr. Kirk has assigned his right to Mr. Richard S. Risley, of Philadelphia.

Antiquity of Mechanical Science.—We read in Genesis, that ships were as old, even on the Mediterranean, as the days of Jacob. We likewise read that the Philistines brought thirty thousand chariots into the field against Saul; so that chariots were in use 1070 years before Christ. And about the same time architecture was brought into Europe. And 1030 years before Christ, Ammon built long and tall ships with sails, on the Red Sea and the Mediterranean. And, about ninety years after, the ship Argo was built; which was the first Greek vessel that ventured to pass through the sea, by help of sails, without sight of land, being guided only by the stars. Dædalus also, who lived 980 years before Christ, made sails for ships, and invented several sorts of tools, for carpenters and joiners to work with. He also made several moving statues, which could walk or run of themselves. And, about 800 years before Christ, we find in 2 Chron. xv. that Uzziah made in Jerusalem, engines, invented by cunning men, to be on the towers and upon the bulwarks, to shoot arrows and great stones withal. Corn-mills were early invented; for we read in Deuteronomy, that it was not lawful for any man to take the nether or the upper mill-stone to pledge; yet water was not applied to mills before the year of Christ 600, nor wind-mills used before the year 1200. Likewise, 580 years before Christ, we read in Jeremiah xviii. of the potter's wheel. Architas was the first that applied mathematics to mechanics, but left no mechanical writings behind him: he made a wooden pigeon that could fly about. Archimedes, who lived about 200 years before Christ, was a most subtle geometer and mechanic. He made engines that drew up the ships of Marcellus at the siege of Syracuse; and others that would cast a stone of a prodigious weight to a great distance, or else several lesser stones, as also darts and arrows; but there have been many fabulous reports concerning these engines. He also made a sphere which showed the motions of the sun, moon, and planets. And Posidonius, afterwards, made another which showed the same thing. In these days, the liberal arts flourished, and learning met with proper encouragement; but, afterwards, they became neglected for a long time. Aristotle, who lived about two hundred and ninety years before Christ, was one of the first that writ any methodical discourse of mechanics. But, at this time, the art was contained in a very little compass, there being scarce any thing more known about it than the six mechanical powers. In this state, it continued till the sixteenth century, and then clockwork was invented; and, about 1650, were the first clocks made. At this time, several of the most eminent mathematicians began to consider mechanics; and, by their study and industry, have prodigiously enlarged its bounds, and made it a most comprehensive science. It extends through heaven and earth; the whole universe, and every part of it, is its subject. Not one particle of matter but what comes under its laws. For what else is there in the visible world, but matter and motion? and the properties and affections of both these are the subject of mechanics.—[Emerson.]

The Trial Chronometers at the Royal Observatory. [From the London Nautical Magazine.]

One of the first objects of peace in all civilized countries is the advancement of the arts and sciences; and of the numerous acquisitions which they have made in England during the last few years, the perfection of the chronometer is not the least important. The consequence and value of this machine to a country so "essentially maritime" as Great Britain, has justly obtained it the attention and patronage of Government; and for the last ten years its improvement has become the object of national reward. In fact, the sum of £500 has been annually expended with this design, in the purchase of the best chronometers that the country can produce. Previous to the year 1828 that sum had been divided into £300 and £200, for the purchase of the two best chronometers; but since that time it has been distributed among the three best, in the proportion of £200,

£170, and £130, according to their respective qualities. We shall see that this measure has been attended with salutary effect, for, while it has encouraged the art of constructing the chronometer, it has secured the best of them for the use of the Royal Navy. It has also excited an honorable competition, which has been the means of bringing them to their present perfect condition : one which, until some fresh discovery takes place in their construction, does not seem likely to be surpassed. Another good effect has attended this measure on the part of government. Until the establishment of trial chronometers at the Royal Observatory, the public had no criterion to guide them in deciding on their merits, and consequently their proportional value. Until the absolute daily rates were published in their regular monthly forms, as they are found by comparison at the Observatory, the dark ages of the chronometer may be said to have prevailed : for a veil of darkness hung over the performance of this invaluable machine, and all was uncertainty and conjecture respecting it. The fame of a solitary one now and then broke through this spell, and we heard of its making the land to a mile ; but this was considered a *rara avis*, and the owner of it fortunate in his possession. Even Government knew nothing about it, for it was not satisfactorily established what constituted a good chronometer. But, by the rigid trial which they undergo, the good were soon distinguished from the bad, and the state of the art in this country was quickly ascertained.

In 1822 the system of the trial chronometers at the Royal Observatory was established, and in order to ascertain the condition of the art, a reward of £300 and £200 was offered by the legislature for the two best chronometers. Notice was published, that any chronometers might be sent to the Royal Observatory, on trial, for the reward, provided that they were the property of the depositor, and that he was a chronometer maker by profession. As might be expected, chronometers rushed in from every quarter; for, on referring to the printed monthly reports of the Observatory, we find no less than thirty-one were deposited; and it is to be presumed, that those who sent them were their makers, whose names they severally bore.

The result of the first trial was, that, according to the method of deciding on their qualities, the trial number of one, Barraud's, No. 957, was 11,29 seconds, while that of Pennington, 155, was 12,87 seconds: results very different from those of the present day, but sufficient to show the condition of the art.

We will here take the opportunity of showing the method by which the merits of a chronometer are decided by what is termed its trial number : a method which we believe was proposed by the late Dr. Young, being the result of an extensive mathematical reasoning.

The trial number is derived from the following formula ; and the superiority assigned, accordingly, to the smallness of this number.

Put R=the greatest *mean monthly* rate, per diem.
r=the least do. do.
R'=the greatest daily rate in each month.
r'=the least do. do.
n=No. of months trial.

Make $(R'-r')=z$

And put z, z', z'', z''', &c., for each successive month. The Trial No. then is

$$2(R-r)+\frac{1}{n}\times(z, z', z'', z''',)\ \&c.$$

$$=2(R-r)+\frac{\Sigma\,(R'-r')}{n}$$ where Σ denotes the successive sums of z, z', z'' &c.

That is, by taking the difference of the greater and lesser mean monthly rate, and multiplying the same by 2, and adding thereto the mean of the monthly extreme variations.

EXAMPLE.

		Mean Rate.	Extreme Variation.
1830,	October	—0s69	0s9
	November	—0,54	2,1
	December	—0,85	2,0
1831,	January	—0,67	1,8
	February	—0,58	1,1
	March	—0,54	1,1
	April	—0,31	1,2
	May	—0,76	2,0
	June	—0,95	1,3
	July	—1,01	1,9
	August	—0,82	1,4
	September	—0,60	1,5
		Mean	1,53

Greater rate in July	1s,01
Lesser do. in April	0, 31
Difference	0, 70
Difference × 2	1, 40
Mean of Extreme Variation	1, 53
Trial Number	2, 93

Thus instituted, the annual trials proceeded regularly at the Observatory; and at the commencement of the 6th trial, in July, 1827, a notice was given, that "No chronometer is to be entitled to the first premium if the trial number shall exceed six seconds, nor to the second if the trial number shall

exceed ten seconds. This at once shows that it had been tolerably well ascertained what were the limits to be allowed to a good chronometer. We have seen that 11s,29 and 12s,87 had been the trial numbers of the two first best chronometers, and we now find it determined that six seconds was to be the trial number for the first prize; and that unless the second chronometer came within ten seconds, it was not to be entitled to a premium; both of which limits were within those of the best at the commencement.

In the trial of 1828, the distribution of the whole sum of £500, into three portions, took place in the manner we have before observed, and the trial numbers were respectively established as follows:

For the 1st premium of £200, not exceeding 5 seconds—2d, £170, not exceeding 6 seconds—3d, £130, not exceeding 7½; showing a reduction of one second in the trial number for the first premium—of four seconds in that for the second—and for the third, a number two and a half seconds less than that which had been first established for the second.

In November, 1831, at the commencement of the tenth annual trial, the limits of the trial numbers for obtaining the premiums were again reduced, and established as follows: For the 1st, not exceeding 3½ seconds —2d, not exceeding 4½ seconds—3d, not exceeding 6 seconds. Thus making the third rate chronometer as good as the second of the former trials; the trial number of the second within half a second of that of the first in the former trials; and the trial number of the first a second and a half less than the first of the preceding trials. This alone furnishes us with a tolerable criterion to judge of the state of the art in 1831, compared with what it was in 1821.

The tenth annual trial has just terminated, and we find a still further reduction in the trial numbers, which now stand as those established for the eleventh trial. They are as follows: For the 1st, not exceeding 2½ seconds—2d, not exceeding 3½ seconds—3d, not exceeding 4½ seconds; showing another reduction of one second on the two first, and a second and a half on the limits of the third trial number. It might be asked, can these limits be attained by a chronometer? To which we may reply, that they have been; and if the first should not be reached, Government will be no loser, as it will still have the best chronometer, and the maker will obtain a handsome reward.

We shall now lay before our readers the following table, showing the prize chronometers since the first establishment of the trials, the names of their makers, their trial numbers, and the number of chronometers deposited at the Observatory to compete for the prizes at the commencement, and the number left at the end, of each annual trial.

Year.	Premiums.	Makers' Names and Residences.	Number of Chronometer.	Trial Number.	Actual extreme variation in twelve months.	Extremes of Thermometer.	Number of Chronometers. Deposited for Trial.	Number of Chronometers. Left at the end of the Trial.
1823.	First	Mr. Barraud, Cornhill	957	11s29	3.86	25 to 80	31	16
	Second	Mr. Pennington, Camberwell	154	12.87	5.13			
1824.	First	Mr. Murray, Cornhill	816	4.44	1.11	34 to 70	36	18
	Second	Mr. Cathro, Kirby street, Hatton Garden	1512	6.84	1.88			
1825.	First	Mr. Widenham, East street, Red Lion square	929	5.44	1.80	36 to 70	31	9
	Second	Mr. French, Royal Exchange	1640	6.12	1.85			
1826.	First	Mr. French, Royal Exchange	20–3912	2.62	0.61	25 to 82	48	13
	Second		975	3.46	0.99			
1827.	First	Messrs. M'Cabe & Strachan, Cornhill	167	4.68	1.50	29 to 79	59	16
	Second	Mr. Young, Islington	78	5.65	2.00			
1828.	First	Mr. Guy, Radnor street, City road	1410	4.41	1.41	35 to 78	58	25
	Second	Mr. Young, Islington	85	4.52	1 23			
1829.	First	Mr. Dent, 43 King street, Long Acre	114	2.27	0.54	29 to 73	79	26
	Second	Mr. Carter, Tooley street	131	3.80	0.79			
	Third	Mr. Molyneux, 44 Devonshire st., Queen Sqr.	943	4.00	1.28			
1830.	First	Mr. Baker, 6 Angel Terrace, Pentonville	865	3.59	0.98	28 to 80	57	23
	Second	Mr. Carter, Tooley street	137	4.04	1.09			
	Third	Mr. Murray, Cornhill	640	4.34	1.13			
1831.	First	Mr. Cotterell, 163 Oxford street	311	2.93	0.70	27 to 78	73	29
	Second	Mr. Frodsham, Change Alley	2	3.65	0.86			
	Third	Mr. Webster, 43 Cornhill	665	3.73	0.89			
1832.	First	Mr. Molyneux	1038	2.82	0.67	39 to 78	62	22
	Second	Mr. Young	110	2.97	0.82			
	Third	Mr. Webster	695	3.09	0.86			

A glance at the foregoing table will show the truth of our observation on setting out—that a degree of perfection has been attained in the construction of the chronometer, which is not likely to be surpassed until some further discovery be made in it. This must be directed to the balance-spring, and what is termed the "compensation" in the balance-wheel, or the allowance for change of temperature, in which the whole art of chronometer-making now lies. Mr. Arnold's escapement has rendered that part of the construction as complete as can be desired at present, although it is said not to be adopted by our neighbors, the French; and his new lever compensation is a material improvement on those of the circular construction, although the latter display a depth of ingenuity, and acquaintance with the principles of the art, which can only result from many years' application to it.

Many ingenious and highly interesting experiments have been made on these parts of the chronometer, with the view of leading to some discovery respecting them—an account of which we hope to give our readers in some future numbers of our work. Mr. Arnold has already had twelve chronometers deposited at the Royal Observatory, during the last six months, for the purposes of experiment, by the permission of the Lords Commissioners of the Admiralty; and as a proof of his zeal for bringing the chronometer to perfection, he is anxious to place the sum of £100 in the hands of a public board, to be the reward of any *practical* maker who will simplify and improve the performance of the machine.

Memoir of the Life of Eli Whitney. [From the American Journal of Science and Arts.]

Eli Whitney was born in Westborough, Worcester county, Massachusetts, December 8, 1765. The paternal ancestors of Mr. Whitney emigrated from England among the early settlers of Massachusetts, and their descendants were among the most respectable farmers of Worcester county. His maternal ancestors, of the name of Fay, were also English emigrants, and ranked among the substantial yeomanry of Massachusetts. A family tradition respecting the occasion of their coming to this country may serve to illustrate the history of the times. The story is, that about two hundred years ago, the father of the family, who resided in England, a man of large property and great respectability, called together his five sons, and addressed them thus: "America is to be a great country: I am too old to emigrate to it myself, but, if any of you will go, I will give him a double share of my property." The youngest son instantly declared his willingness to go, and his brothers gave their consent. He soon set off for the New World, and landed at Boston, in the neighborhood of which place he purchased a large tract of land, where he enjoyed the satisfaction of receiving two visits from his venerable father.

Indications of Eli's mechanical genius were developed at a very early age. Of his early passion for such employments his sister gives the following account: "Our father had a work-shop, and sometimes made wheels of different kinds, and chairs. He had a variety of tools, and a lathe for turning chair-posts. This gave my brother an opportunity of learning the use of tools when very young. He lost no time, but as soon as he could handle tools he was always making something in the shop, and seemed not to like working on the farm. On a time, after the death of our mother, when our father had been absent from home two or three days, on his return he inquired of the housekeeper what the boys had been doing? She told him what B. and J. had been about. But what has Eli been doing? said he. She replied, he had been making a fiddle. 'Ah!' (added he despondingly,) 'I fear Eli will have to take his portion in fiddles.' He was at this time about twelve years old. His sister adds, that his fiddle was finished throughout, like a common violin, and made tolerably good music. It was examined by many persons, and all pronounced it to be a remarkable piece of work for such a boy to perform. From this time he was employed to repair violins, and had many nice jobs, which were always executed to the entire satisfaction, and often to the astonishment, of his customers. His father's watch being the greatest piece of mechanism that had yet presented itself to his observation, he was extremely desirous of examining its interior construction, but was not permitted to do so. On Sunday morning, observing that his father was going to meeting, and would leave at home the wonderful little machine, he immediately feigned illness as an apology for not going to church. As soon as the family were out of sight, he flew to the room where the watch hung, and, taking it down, he was so delighted with its motions, that he took it

all in pieces before he thought of the consequences of his rash deed; for his father was a stern parent, and punishment would have been the reward of his idle curiosity had the mischief been detected. He, however, put the work all so neatly together, that his father never discovered his audacity until he himself told him many years afterwards."

When Whitney was fifteen or sixteen years of age, he suggested to his father an enterprize which was an earnest of the similar undertakings in which he engaged on a far greater scale in later life. This being the time of the Revolutionary War, nails were in great demand, and bore a high price. At that period nails were made chiefly by hand, with little aid from machinery. Young Whitney proposed to his father to procure for him a few tools, and to permit him to set up the manufacture. His father consented, and he went steadily to work, and suffered nothing to divert him from his task until his day's work was completed. By extraordinary diligence he gained time to make tools for his own use, and to put in knife blades, and to perform many other curious little jobs, which exceeded the skill of the country artisans. At this laborious occupation the enterprising boy wrought alone, with great success, and with much profit to his father, for two winters—pursuing the ordinary labors of the farm during the summers. At this time he devised a plan for enlarging his business and increasing his profits. He whispered his scheme to his sister, with strong injunctions of secrecy; and requesting leave of his father to go to a neighboring town, without specifying his object, he set out on horseback in quest of a fellow laborer. Not finding one so easily as he had anticipated, he proceeded from town to town, with a perseverance which was always a strong trait of his character, until, at the distance of forty miles from home, he found such a workman as he desired. He also made his journey subservient to his improvement in mechanical skill, for he called at every workshop on his way, and gleaned all the information he could respecting the mechanic art.

At the close of the war the business of making nails was no longer profitable; but a fashion prevailing among the ladies of fastening on their bonnets with long pins, he contrived to make those with such skill and dexterity that he nearly monopolized the business, although he devoted to it only such seasons of leisure as he could redeem from the occupations of the farm, to which he now principally betook himself. He added to this article the manufacture of walking canes, which he made with peculiar neatness.

In respect to his proficiency in learning, while young, we are informed that he early manifested a fondness for figures, and an uncommon aptitude for arithmetical calculations, though, in the other rudiments of education, he was not particularly distinguished. Yet, at the age of fourteen he had acquired so much general information as to be regarded, on this account, as well as on account of his mechanical skill, as a very remarkable boy.

From the age of nineteen, young Whitney conceived the idea of obtaining a liberal education; but being warmly opposed by his step-mother, he was unable to procure the decided consent of his father until he had reached the age of twenty-three years But partly by the avails of his manual labor, and partly by teaching a village school, he had been so far able to surmount the obstacles thrown in his way, that he had prepared himself for the Freshman class in Yale College, which he entered in May, 1789. As we are soon to accompany Mr. Whitney beyond the sphere of his domestic relations, we may mention here that he finished his collegiate education with little expense to his father. His last college bills were indeed paid by him, but the money was considered as a loan, and for it the son gave his note, which he afterwards duly cancelled. After the decease of his father he took an active part in the settlement of his estate, but generously relinquished all his parsimony, for the benefit of the other members of the family.

The propensity of Mr. Whitney to mechanical inventions and occupations was frequently apparent during his residence at college. On a particular occasion, one of the tutors happening to mention some interesting philosophical experiment, regretted that he could not exhibit it to his pupils, because the apparatus was out of order, and must be sent abroad to be repaired. Mr. Whitney proposed to undertake this task, and performed it greatly to the satisfaction of the Faculty of the College.

A carpenter being at work upon one of the buildings of the gentleman with whom Mr. Whitney boarded, the latter begged permission to use his tools during the intervals of study; but the mechanic being a

man of careful habits, was unwilling to trust them with a student, and it was only after the gentleman of the house had become responsible for all damages, that he would grant the permission. But Mr. Whitney had no sooner commenced his operations than the carpenter was surprised at his dexterity, and exclaimed, "there was one good mechanic spoiled when you went to college."

Soon after Mr. Whitney took his degree, in the autumn of 1792, he entered into an engagement with a Mr. B. of Georgia, to reside in his family as a private teacher. Mr. Whitney had scarcely set his foot in Georgia, however, before he was met by a disappointment which was an earnest of that long series of adverse events which, with scarcely an exception, attended all his future negociations in the same State. On his arrival he was informed that Mr. B. had employed another teacher, leaving Whitney entirely without resources, and without friends, except in the family of General Greene, of Mulberry Grove, near Savannah, with whom he had accidentally formed an acquaintance in his journey into Georgia. In these benevolent people, however, his case excited much interest, and Mrs. Greene kindly said to him, 'My young friend, you propose studying the law; make my house your home—your room, your castle—and there pursue what studies you please.' He accordingly commenced the study of law under that hospitable roof.

Mrs. Greene was engaged in a piece of embroidery, in which she employed a peculiar kind of frame called a *tambour*. She complained that it was badly constructed, and that it tore the delicate threads of her work. Mr. Whitney, eager for an opportunity to oblige his hostess, set himself at work, and speedily produced a tambour frame made on a plan entirely new, which he presented to her. Mrs. Greene and her family were greatly delighted with it, and thought it a wonderful proof of ingenuity.

Not long afterwards, a large party of gentlemen came from Augusta and the upper county, to visit the family of Gen. Greene, consisting principally of officers who had served under the General in the Revolutionary army. Among the number were Major Bremen, Major Forsyth, and Major Pendleton. They fell into conversation upon the state of agriculture among them, and expressed great regret that there was no means of cleaning the green seed cotton, or separating it from its seed, since all the lands which were unsuitable for the cultivation of rice would yield large crops of cotton. But until ingenuity could devise some machine which would greatly facilitate the process of cleaning, it was in vain to think of raising cotton for market. Separating one pound of the clean staple from the seed was a day's work for a woman; but the time usually devoted to picking cotton was the evening, after the labor of the field was over. Then the slaves, men, women, and children, were collected in circles, with one, whose duty it was to rouse the dozing and quicken the indolent. While the company were engaged in this conversation, "Gentlemen," said Mrs. Greene, "apply to my young friend, Mr. Whitney—he can make any thing." Upon which she conducted them into a neighboring room, and showed them her tambour frame, and a number of toys which Mr. Whitney had made, or repaired, for the children. She then introduced the gentlemen to Whitney himself, extolling his genius, and commending him to their friendship. He modestly disclaimed all pretensions to mechanical genius; and when they named their object, he replied that he had never seen cotton or cotton seed in his life. Mrs. G. said to one of the gentlemen, "I have accomplished my aim. Mr. Whitney is a very deserving young man, and to bring him into notice was my object. The interest which our friends now feel for him, will, I hope, lead to his getting some employment to enable him to prosecute the study of the law."

But a new turn, that no one of the company dreamed of, had been given to Mr. Whitney's views. It being out of season for cotton in the seed, he went to Savannah, and searched among the warehouses and boats until he found a small parcel of it. This he carried home, and communicated his intentions to Mr. Miller, who warmly encouraged him, and assigned him a room in the basement of the house, where he set himself at work with such rude materials and instruments as a Georgia plantation afforded. With these resources, however, he made tools better suited to his purpose, and drew his own wire, (of which the teeth of the earliest gins were made,) an article which was not at that time to be found in the market of Savannah. Mrs. Greene and Mr. Miller were the only persons ever admitted to his work-shop, and the only persons who knew in what way he was employing himself. The many hours he spent in his mysterious pursuits afforded matter of great curiosity, and often of raillery, to the

younger members of the family. Near the close of the winter the machine was so nearly completed as to leave no doubt of its success.

Mrs. Greene was eager to communicate to her numerous friends the knowledge of this important invention, peculiarly important at that time, because then the market was glutted with all those articles which were suited to the climate and soil of Georgia, and nothing could be found to give occupation to the negroes, and support to the white inhabitants. This opened suddenly to the planters boundless resources of wealth, and rendered the occupations of the slaves less unhealthy and laborious than they had been before.

Mrs. Greene, therefore, invited to her house gentlemen from different parts of the State, and, on the first day after they had assembled, she conducted them to a temporary building, which had been erected for the machine, and they saw, with astonishment and delight, that more cotton could be separated from the seed in one day, by the labor of a single hand, than could be done in the usual manner in the space of many months.

The individual, however, who contributed most to incite Whitney to persevere in the undertaking was *Phineas Miller*, Esq. Mr. Miller was a native of Connecticut, and a graduate of Yale College. Like Mr. Whitney, soon after he had completed his education at college, he came to Georgia as a private teacher, in the family of General Greene, and after the decease of the General, he became the husband of Mrs. Greene. He had qualified himself for the profession of law, and was a gentleman of cultivated mind and superior talents; but he was of an ardent temperament, and therefore well fitted to enter with zeal into the views which the genius of his friend had laid open to him. He had also considerable funds at command, and proposed to Mr. Whitney to become his joint adventurer, and to be at the whole expense of maturing the invention until it should be patented. If the machine should succeed in its intended operation, the parties agreed, under legal formalities, "that the profits and advantages arising therefrom, as well as all privileges and emoluments to be derived from patenting, making, vending, and working the same, should be mutually and equally shared between them." This instrument bears date May 27, 1793, and immediately afterwards they commenced business under the firm of *Miller & Whitney*.

An invention so important to the agricultural interest (and, as it has proved, to every department of human industry,) could not long remain a secret. The knowledge of it soon spread through the State, and so great was the excitement on the subject, that multitudes of persons came from all quarters of the State to see the machine; but it was not deemed safe to gratify their curiosity until the patent right had been secured. But so determined were some of the populace to possess this treasure, that neither law nor justice could restrain them; they broke open the building by night and carried off the machine. In this way the public became possessed of the invention; and before Mr. Whitney could complete his model and secure his patent, a number of machines were in successful operation, constructed with some slight deviation from the original, with the hope of evading the penalty for violating the patent-right.

As soon as the copartnership of Miller & Whitney was formed, Mr. Whitney repaired to Connecticut, where, as far as possible, he was to perfect the machine, obtain a patent, and manufacture, and ship for Georgia, such a number of machines as would supply the demand.

His return to Georgia was, however, delayed until April. The importunity of Mr. Miller's letters, written during the preceding period, urging him to come on, evinces how eager the Georgia planters were to enter the new field of enterprize which the genius of Whitney had laid open to them.

"Do not let a deficiency of money, do not let any thing, (says Mr. Miller,) hinder the speedy construction of the Gins. The people of the country are almost running mad for them, and much can be said to justify their importunity."

The general resort of the planters to the cultivation of cotton, and its consequent production in vast quantities, the value of which depended entirely upon the chance of getting it cleaned by the gin, created great uneasiness, which first displayed itself in this pressure upon Miller and Whitney, and afterwards afforded great encouragement to marauders upon the patent right, who were now becoming numerous and audacious.

The *roller gin* was at first the most formidable competitor with Whitney's machine. It extricated the seeds by means of rollers, crushing them between revolving cylinders, instead of disengaging them by means of teeth. The fragments of seeds which remained in the cotton, rendered its execution

much inferior in this respect to Whitney's gin, and it was also much slower in its operation.

But a still more formidable rival appeared early in the year 1795, under the name of the *Saw Gin.* It was Whitney's gin, except that the teeth were cut in circular rims of iron, instead of being made of wires, as was the case in the earlier forms of the patent gin. The idea of such teeth had early occurred to Mr. Whitney, as he afterwards established by legal proof. But they would have been of no use except in connection with the other parts of his machine; and, therefore this was a palpable attempt to evade the patent right, and it was principally in reference to this that the law-suits were afterwards held.

In March, 1795, in the midst of these perplexities and discouragements, Mr. Whitney went to New-York on business, and was detained there three weeks by an attack of fever and ague, the seeds of which had been sown the previous season in Georgia. As soon as he was able to leave the house, he embarked on board a packet for New-Haven. On his arrival at this place, he was suffering under one of those chills which precede the fever. As was usual on the arrival of the packet, people came on board to welcome their friends, and to exchange salutations, when Mr. Whitney was informed that, on the preceding day, his shop, with all his machines and papers, had been consumed by fire. Thus suddenly was he reduced to absolute bankruptcy, having debts to the amount of four thousand dollars, without any means of making payment. Mr. Whitney, however, had not a spirit to despond under difficulties and disappointments, but was aroused by them to still more vigorous efforts.

Mr. Miller also, on hearing of this catastrophe, manifested a kindred spirit. The letters written by Mr. Whitney on the occasion we have not been able to obtain; but the reply of Mr. Miller indicates what were the feelings of both parties. It may be of service to enterprising young men, who meet with misfortunes, to read an extract or two:

"I think with you (says Mr. M.), that we ought to meet such events with equanimity. We have been pursuing a valuable object by honorable means; and I trust that all our measures have been such as reason and virtue must justify. It has pleased Providence to postpone the attainment of this object. In the midst of the reflections which your story has suggested, and with feelings keenly awake to the heavy, the extensive injury we have sustained, I feel a secret joy and satisfaction that you possess a mind in this respect similar to my own—that you are not disheartened—that you do not relinquish the pursuit—and that you will persevere and endeavor, at all events, to attain the main object. This is exactly consonant to my own determinations. I will devote all my time, all my thoughts, all my exertions, and all the money I can earn or borrow, to encompass and complete the business we have undertaken; and if fortune should, by any future disaster, deny us the boon we ask, we will at least deserve it. It shall never be said that we have lost an object which a little perseverance could have attained. I think, indeed, it will be very extraordinary, if two young men in the prime of life, with some share of ingenuity, with a little knowledge of the world, a great deal of industry, and a considerable command of property, should not be able to sustain such a stroke of misfortunes as this, heavy as it is."

While struggling with these multiplied misfortunes, intelligence was received from England, which threatened to give a final blow to all their hopes. It was, that the English manufacturers condemned the cotton cleaned by their machines, on the ground that the staple was greatly injured.

At this time (1796) Miller and Whitney had thirty gins at eight different places in the State of Georgia, some of which were carried by horses or oxen, and some by water. A number of these were standing still for want of the means of supplying them. The company had also invested about $10,000 in real estate, which was suited only to the purposes of ginning cotton. All things now conspired to threaten them with deep insolvency.

We have before us a letter written by Mr. Whitney, dated Oct. 7th, 1797, from which it will be seen what was the state of his affairs, and of his feelings, at this period: "The extreme embarrassments (says he) which have been for a long time accumulating upon me, are now become so great that it will be impossible for me to struggle against them many days longer. It has required my utmost exertions to exist, without making the least progress in our business. I have labored hard against the strong current of disappointment, which has been threatening to carry us down the cataract, but I have labored with a shattered oar, and struggled in vain, unless some speedy relief is obtained."

However, brighter prospects seemed now to be opening upon them, from the more favorable reports that were made respecting the quality of their cotton. Respectable manufacturers, both at home and abroad, gave favorable certificates; and retailing merchants sought for the cotton cleaned by Whitney's gin, because it was greatly preferred by their customers to any other in the market. This favorable turn in public opinion would have restored prosperity to the company, had not the encroachments on their patent right become so extensive as almost to annihilate its value.

In April, 1799, Mr. Miller writes as follows: "The prospect of making any thing by ginning in this State is at an end. Surreptitious gins are erected in every part of the country; and the jurymen at Augusta have come to an understanding among themselves, that they will never give a cause in our favor, let the merits of the case be as they may."

Many of the planters of South Carolina having expressed an opinion, that, if an application were made to their legislature by the citizens to purchase the right of the patentees for that State, there was no doubt that it would be done to the satisfaction of all parties. Accordingly Mr. Whitney repaired to Columbia, taking the city of Washington in his way, where he was furnished with very obliging letters from President Jefferson and Mr. Madison, then Secretary of State: testimonials which, no doubt, were of great service to him in his subsequent negociations. Soon after the opening of the session of the legislature in the month of December, 1801, the business was regularly brought before the legislature, and a joint committee of both Houses appointed to treat with the patentees.

We subjoin an extract of a letter addressed at this time by Mr. Whitney to his friend Stebbins, both as a statement of the particulars relating to the contract, and as evincive of the feelings of the writer:

"Columbia, S. C., Dec. 20, 1801.

"Dear Stebbins,—I have been at this place a little more than two weeks, attending the legislature. They closed their session at ten o'clock last evening. A few hours previous to their adjournment, they voted to purchase, for the State of South Carolina, my patent right to the machine for cleaning cotton at fifty thousand dollars, of which sum twenty thousand is to be paid in hand, and the remainder in three annual payments of ten thousand dollars each. This is selling the right at a great sacrifice. If a regular course of law had been pursued, from two to three hundred thousand dollars would undoubtedly have been recovered. The use of the machine here is amazingly extensive, and the value of it beyond all calculation. It may, without exaggeration, be said to have raised the value of seven-eighths of all the three southern States from fifty to one hundred per cent. We get but a song for it in comparison with the worth of the thing; but it is securing something. It will enable Miller and Whitney to pay all their debts, and divide something between them. It establishes a precedent, which will be valuable as it respects our collections in other States, and I think there is now a fair prospect that I shall in the event realize property enough to render me comfortable, and in some measure independent."

In December, 1802, Mr. Whitney negociated a sale of his patent right with the State of North Carolina. The legislature laid a tax of two shillings and sixpence upon every saw* employed in ginning cotton, to be continued for five years, which sum was to be collected by the sheriffs in the same manner as the public taxes; and after deducting the expenses of collection, the avails were faithfully paid over to the patentee. At that time the culture of cotton had made comparatively little progress in the State of North Carolina, but in proportion to the amount of interest concerned, this compensation was regarded by Mr. Whitney as more liberal than that received from any other source.

While these encouraging prospects were rising in North Carolina, Mr. Goodrich, an agent of the company, was entering into a similar negociation with the State of Tennessee. The importance of the machine began to be universally acknowledged in that State, and various public meetings of the citizens were held, in which were adopted resolutions strongly in favor of a public contract with Miller and Whitney. Accordingly the legislature of Tennessee, at their session in 1804, passed an act laying a tax of thirty-seven and a half cents per annum on every saw for the period of four years.

But while a fairer day seemed dawning upon the company in this quarter, an unexpected and threatening cloud was rising in another. It was during Mr. Whitney's negociation with the legislature of North Carolina that he received intelligence that the

* Some of the gins had forty saws.

legislature of South Carolina had annulled the contract made with Miller and Whitney the preceding year, had suspended payment of the balance (thirty thousand dollars) due them, and instituted a suit for the recovery of what had already been paid to them.

The ostensible causes of this extraordinary measure, adopted by the legislature of South Carolina, were a distrust of the validity of the patent right, and failure on the part of the patentees to perform certain conditions agreed on in the contract. Great exertions had constantly been made in Georgia to impress the public with the notion that Mr. Whitney was not the original inventor of the cotton gin, somebody in Switzerland having conceived the idea of it before him; and especially that he was not entitled to the credit of the invention in its improved form, in which saws were used instead of wire teeth, inasmuch as his particular form of the machine was introduced by one Hodgin Holmes. It was on these grounds that the Governor of Georgia, in his message to the legislature of that State in 1803, urged the inexpediency of granting any thing to Miller and Whitney.

Popular feeling, stimulated by the most sordid motives, was now awakened throughout all the cotton-growing States. Tennessee followed the example of South Carolina in suspending the payment of the tax laid upon cotton gins, and a similar attempt was made at a subsequent session of the legislature of North Carolina, but it wholly failed, and the report of a committee offering a resolution, that "the contract ought to be fulfilled with punctuality and good faith," was adopted by both branches of the legislature.

There were also high minded men in South Carolina, who were indignant at the dishonorable measures adopted by their legislature of 1803, and their sentiments had impressed the community so favorably with regard to Mr. Whitney, that at the session of 1804 the legislature not only rescinded what the previous legislature had done, but signified their respect for Mr. Whitney by marked commendations.

At this time a new and unexpected responsibility devolved on Mr. Whitney, in consequence of the death of his partner, Mr. Miller, who died on the 7th December, 1803.

Mr. Whitney was now left alone to contend singly against those difficulties which had for a series of years almost broken down the spirits of both the partners. But the favorable issue of the affairs of Mr. Whitney in South Carolina during the subsequent year, and the generous receipts that he obtained from the avails of his contracts with North Carolina, relieved him from the embarrassments under which he had so long groaned, and made him in some degree independent. Still, no small portion of the funds thus collected in North and South Carolina was expended in carrying on the fruitless, endless law-suits in Georgia.

In the United States Court, held in Georgia in December, 1807, Mr. Whitney obtained a most important judgment, in a suit brought against a trespasser of the name of Fort. It was on this trial that Judge Johnson gave the decision in his favor, to which we have before alluded.

This favorable decision, however, did not put a final step to aggression. At the next session of the United States Court, two other actions were brought, and verdicts for damages gained, of two thousand dollars in one case, and one thousand and five hundred dollars in the other.

The influence of these decisions, however, availed Mr. Whitney very little, for now the term of his patent right was nearly expired. More than sixty suits had been instituted in Georgia before a single decision on the merits of his claims was obtained, and at the period of this decision, thirteen years of his patent had expired.

In 1798, Mr. Whitney became deeply impressed with the uncertainty of all his hopes founded upon the cotton gin, notwithstanding their high promise, and he began to think seriously of devoting himself to some business in which superior ingenuity, seconded by uncommon industry, qualifications which he must have been conscious of possessing in no ordinary degree, would conduct him by a slow but sure route to a competent fortune; and we have always considered it indicative of a solid judgment, and a well balanced mind, that he did not, as is frequently the case with men of inventive genius, become so poisoned with the hope of vast and sudden wealth as to be disqualified for making a reasonable provision for life, by the sober earnings of frugal industry.

The enterprize which he selected in accordance with these views was the manufacture of arms for the United States. He accordingly addressed a letter to the Hon. Oliver Wolcott, Secretary of the Treasury, and through his influence obtained a contract for ten thousand stand of arms, amounting (as the price of each musket was to be thirteen dollars and forty cents) to one hundred

and thirty-four thousand dollars—an undertaking of great responsibility, considering the limited pecuniary resources of the undertaker. This contract was concluded on the 14th of January, 1798, and four thousand were to be delivered on or before the last day of September of the ensuing year, and the remaining six thousand within one year from that time, so that the whole contract was to be fulfilled within a little more than the period of two years: and for the due fulfilment of it, Mr. Whitney entered into bonds to the amount of thirty thousand dollars. He must have engaged in this undertaking resolved "to attempt great things," without stopping to weigh all the chances against him, for as yet the works were all to be erected, the machinery to be made, and much of it to be invented; the raw materials were to be collected from different quarters, and the workmen themselves, almost without exception, were yet to learn the trade. Nor was it a business with which Mr. Whitney himself was particularly conversant. Mechanical invention, a sound judgment, and persevering industry, were all that he possessed, at first, for the accomplishment of an enterprize which was, at that time, probably greater than any man had ever undertaken in the State of Connecticut.

The site which Mr. Whitney had purchased for his works was at the foot of the celebrated precipice called East Rock, within two miles of New-Haven. This spot, (which is now called Whitneyville), is justly admired for the romantic beauty of its scenery. A waterfall of moderate extent afforded here the necessary power for propelling the machinery. In this pleasant retreat Mr. Whitney commenced his operations with the greatest zeal; but he soon became sensible of the multiplied difficulties which he had to contend with. A winter of uncommon severity set in early, and suspended his labors; and when the spring returned, he found himself so little advanced that he foresaw that he should be utterly unable to deliver the four thousand muskets according to contract. At the end of the first year after the contract was made, instead of four thousand muskets, only five hundred were delivered, and it was eight years, instead of two, before the whole ten thousand were completed. The entire business relating to the contract was not closed until January, 1809, when (so liberally had the government made advances to the contractor) the final balance due to Mr. Whitney was only 2,450 dollars.

In the year 1812, he entered into a new contract with the United States to manufacture for them fifteen thousand stand of arms; and in the mean time he executed a similar engagement (we know not how extensive) for the State of New-York.

It should be remarked, that the utility of Mr. Whitney's labors, during the period of his life which we have now been contemplating, was not limited to the particular business in which he was engaged. Many of the inventions which he made to facilitate the manufacture of muskets, were applicable to most other manufactures of iron and steel. To many of these they were soon extended, and became the nucleus around which other inventions clustered; and at the present time some of them may be recognized in almost every considerable workshop of that description in the United States.

In the year 1812, Mr. W. made application to Congress for the renewal of his patent for the cotton gin. In his memorial he presented a history of the struggles he had been forced to encounter in defence of his right, observing that he had been unable to obtain any decision on the merits of his claim until he had been *eleven years* in the law, and *thirteen years* of his patent term had expired. He set forth, that his invention had been a source of opulence to thousands of the citizens of the United States; that, as a labor-saving machine, it would enable one man to perform the work of a thousand men; and that it furnishes to the whole family of mankind, at a very cheap rate, the most essential article of their clothing. Hence, he humbly conceived himself entitled to a further remuneration from his country, and thought he ought to be admitted to a more liberal participation with his fellow citizens in the benefits of his invention. Although so great advantages had been already experienced, and the prospect of future benefits was so promising, still, many of those whose interest had been most promoted, and the value of whose property had been most enhanced, by this invention, had obstinately persisted in refusing to make any compensation to the inventor. The very men whose wealth had been acquired by the use of this machine, and who had grown rich beyond all former example, had combined their exertions to prevent the patentee from deriving any emolument from his invention. From that State, in which he had first made and where he had first introduced his machine, and which had derived the most signal bene-

fits from it, he had received nothing; and from one State had he received the amount of *half a cent per pound* on the cotton cleaned with his machines in one year. Estimating the value of the labor of one man at twenty cents per day, the whole amount which had been received by him, for his invention, was not equal to the value of the labor saved *in one hour* by his machines then in use in the United States.

Notwithstanding these cogent arguments, the application was rejected by Congress. Some liberal minded and enlightened men from the cotton districts favored the petition; but a majority of the members from that section of the Union were warmly opposed to granting it.

In the midst of these fruitless efforts to secure to himself some portion of the advantages which so many of his fellow citizens were reaping from his ingenuity, his armory proceeded with a sure but steady pace, which bore him on to affluence. For the few following years he occupied himself principally in the concerns of his manufactory, inventing new kinds of machinery, and improving and perfecting the old.

In January, 1817, Mr. Whitney was married to Miss Henrietta F. Edwards, youngest daughter of the honorable Pierpont Edwards, late Judge of the District Court for the State of Connecticut. The fond and quiet scenes of domestic life, after which he had long aspired, but from which he had been debarred by the embarrassed or unsettled state of his affairs, now spread before him in the fairest light. Four children, a son and three daughters, added successively fresh attractions to the family circle. Happy in his home, and easy in his fortune, with a measure of respectability among his fellow citizens, and celebrity abroad, which might well satisfy an honorable ambition, he seemed to have in prospect, after a day of anxiety and toil, an evening unusually bright and serene.

In this uniform and happy tenor, he passed the five following years, when a formidable malady began to make its approaches, by a slow but hopeless progress, which at length terminated his life.

From the 12th November, 1824, his sufferings became almost unremitted, until the 8th January, 1825, when he expired,—retaining his consciousness to the last, closing his own eyes, and making an effort to close his mouth.

In his person, Mr. Whitney was considerably above the ordinary size, of a dignified carriage, and of an open, manly and agreeable countenance. His manners were conciliatory, and his whole appearance such as to inspire universal respect. Among his particular friends no man was more esteemed. Some of the earliest of his intimate associates were also among the latest. With one or two of the bosom friends of his youth he kept up a correspondence by letter for thirty years, with marks of continually increasing regard. His sense of honor was high, and his feelings of resentment and indignation occasionally strong. He could, however, be cool when his opponents were heated; and though sometimes surprized by passion, yet the unparalleled trials of patience which he had sustained did not render him petulant, nor did his strong sense of the injuries he had suffered in relation to the cotton gin impair the natural serenity of his temper.

But the most remarkable trait in the character of Mr. Whitney, aside from his inventive powers, was his *perseverance;* and this is the more remarkable, because it is so common to find men of great powers of mechanical invention defective in this quality. Nothing is more frequent than to see a man of the most fertile powers of invention run from one piece of mechanism to another, leaving the former half finished; or if he has completed any thing, it is usual to find him abandon it to others, too fickle to pursue the advantages he might reap from it, or too sensitive to struggle with the sordid and avaricious, who may seek to rob him of the profits of his invention.

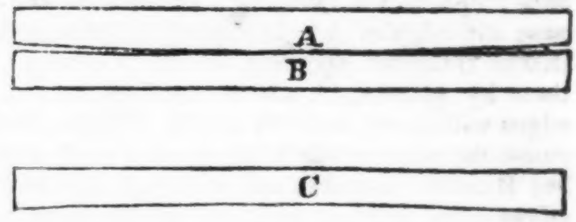
It would be difficult to estimate the full value of Mr. Whitney's labors without going into a minuteness of detail inconsistent with our limits. Every cotton garment bears the impress of his genius, and the ships that transported it across the waters were the heralds of his fame; and the cities that have risen to opulence by the cotton trade must attribute no small share of their prosperity to the inventor of the cotton gin. We have before us the declaration of the late Mr. Fulton, that Arkwright, Watt, and Whitney, (we could add Fulton to the number), were the three men who did most for mankind of any of their contemporaries; and, in the sense in which he intended it, the remark is probably true.

The following observations of a distinguished scholar and statesman, elicited in consequence of a recent visit to the cemetery of New-Haven, evince the estimation in which Mr. Whitney's name is held, by one who is fully capable of appreciating his merits. After alluding to the monument of

Gen. Humphreys, who introduced the fine woolled sheep into the United States, the stranger remarks: "But Whitney's monument perpetuates the name of a still greater public benefactor. His simple name would have been epitaph enough, with the addition, perhaps, of 'the inventor of the cotton gin.' How few of the inscriptions in Westminster Abbey could be compared with that! Who is there that, like him, has given his country a machine—the product of his own skill—which has furnished a large part of its population, 'from childhood to age, with a lucrative employment: by which their debts have been paid off; their capitals increased; *their lands trebled in value.*' It may be said, indeed, that this belongs to the physical and material nature of man, and ought not to be compared with what has been done by the intellectual benefactors of mankind—the Miltons, the Shakspeares, and the Newtons. But it is quite certain that any thing short of the highest intellectual vigor—the brightest genius—is sufficient to invent one of these extraordinary machines. Place a common mind before an oration of Cicero and a steam engine, and it will despair of rivalling the latter as much as the former; and we can by no means be persuaded, that the peculiar aptitude for combining and applying the simple powers of mechanics so as to produce these marvellous operations, does not imply a vivacity of the imagination, not inferior to that of the poet and the orator. And then, as to the effect on society, the machine, it is true, operates, in the first instance, on mere physical elements, to produce an accumulation and distribution of property. But do not all the arts of civilization follow in the train? and has not he, who has trebled the value of land, created capital, rescued the population from the necessity of emigrating, and covered a waste with plenty—has not he done a service to the country, of the highest moral and intellectual character? Prosperity is the parent of civilization, and all its refinements; and every family of prosperous citizens added to the community, is an addition of so many thinking, inventing, moral, and immortal natures."

On Mr. Whitney's tomb is the following inscription:

ELI WHITNEY,
The inventor of the Cotton Gin.
Of useful science and arts, the efficient
patron and improver.
In the social relations of life, a model of excellence.
While private affection weeps at his tomb,
his country honors his memory.
Born December 8, 1765.—Died January 8, 1825.



STRAIGHT EDGES.—Among mechanics there are probably but few who do not appreciate the value of a good straight edge for ascertaining the correctness of their work, and I presume that a description of the method practised, and the theory upon which it is based, will be interesting. There are doubtless many that like myself have thought it absurd, even when told seriously, by good practical workmen, that it was impossible to make *one* straight edge, without making *three*, or that one plate of an air-pump could not be ground flat, unless three were ground at the same time.

When I inquired the reason of this, I could get no other explanation from my informant than that such was the fact. Although at that time I considered the idea ridiculous, I have since discovered that my friend was perfectly correct, and, had he been able to have stated the cause or theory, I feel assured I should have been convinced.

I am aware, in the formation of straight edges, that the size must depend much upon the work to which it is to be applied, yet some regard to the form and dimensions are advisable, as there is a certain proportion more suitable than any other. An eminent English writer (Dr. Birkbeck) observes upon this subject, that in England they are made of thin bars of steel, about one eighth of an inch thick, two inches broad, and should not exceed three feet in length, as they will otherwise be liable to bend.

Three such pieces should be prepared by planishing, and one edge of each made as straight as possible by the common means of filing and planing, when they are perfected by grinding them mutually with each other, fine emery and oil being added to assist the operation. They are finally to be finished with crocus martus, or a species of loam well washed, to separate it from any coarse siliceous particles.

By referring to the cut at the head of our article, we will attempt to show the necessity of making three, to produce one perfect straight edge, and also of repeatedly changing them at proper intervals until each edge is correct. Let A and B represent two steel

bars prepared for grinding; let us then suppose the edge of A to be slightly convex, and that of B slightly concave, or nearly straight, then by grinding A and B together the two edges will meet, but will not be straight, because the convex bar A has ground the lower bar B more concave, and although the two edges come in close contact, yet the form is unchanged, and, however long the grinding should be continued, the object could never be attained.

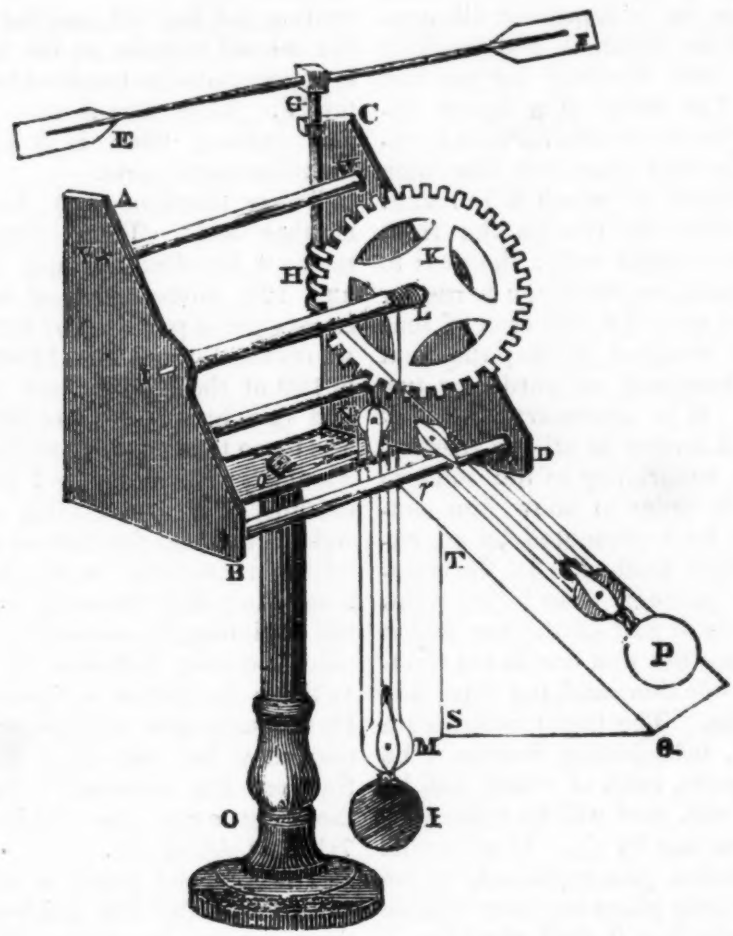
But if we now take a third bar C, the edge of which may be either concave or convex; if concave, and we grind A and C together, the edges of B and C will then be similar, and if placed against one another, the difference will be doubled, and can readily be perceived; these two are then to be ground together, and thus the three edges being alternately and reciprocally ground together, they will mutually cut down and destroy each other's imperfections, and a perfect straight edge will ultimately be produced on all the three.

The same theory applies to the levelling of air-pump plates, and other flat surfaces in machinery where great nicety is required, and the best method of producing them is to proceed in the manner above described.—[Young Mechanic.]

The Walthamstow Wooden Spoon Maker.—I lately happened to meet with a very old and intelligent individual, in the neighborhood of Walthamstow, who was represented to me by his daughter as being no scholar, and who found it convenient to employ his evenings in making one single article—wooden spoons. Every evening in the year, when the evenings were long, he sat down, and with very few tools—a couple of gouges, a plain chisel, a bad file, and two or three knives—he sat down and constructed four spoons every evening, which he formed in a somewhat beautiful manner. You see to what a degree of perfection a mono-mechanic—a man who makes but one thing—can attain by directing his attention simply to the making of spoons. The old artist constructed them of different kinds of wood, all of our own country—some of the plum-tree, the barberry, (which in day-light is very beautiful,) and the pear-tree, and the cherry-tree. He makes four spoons every evening, which he sells at three pence each; and is visited every evening by many persons in consequence of these productions: (they are exceedingly convenient little spoons for tea-caddies, sugar-basins, and so on,) and he feels himself that it is better to make a spoon than to be idle, and that, if he were not sitting still making spoons, he might be sitting somewhere making mischief. He is besides a man of considerable natural taste: he is an entomologist, a butterfly-catcher—but he understands nothing more about them than their commmon names; yet he arranges them very beautifully: he has a very pretty cabinet of butterflies, and moths, and insects, and in the day-time is engaged in that pursuit. He entertains himself likewise in a garden, enjoys delightful health and spirits, and is a very interesting picture of a happy old man.—[Dr. Birkbeck.]

Blacking.—"A Subscriber" asks for a receipt for making blacking, "as his family is numerous, and purchasing at 18d. per bottle is more than he can well afford." We subjoin one which is given in the Annales de Chimie, by the celebrated French chemist Braconot, who pronounces it to be, as compared with all the other known blackings, from Day's to Hunt's, "undoubtedly the cheapest and the best." Macerate one pound of malt in boiling water till every thing soluble is taken up, add 2¼ lbs. of plaster of paris well sifted, and 7 ozs. of lamp-black; then evaporate to the consistence of paste; and finally mix up with 1 lb. 2 ozs. of olive oil. It is said to spread very evenly, dry speedily, and shine brilliantly, with very little brushing; while it neither burns nor injures the leather.—[London M. Mag.]

Steam Boiler Deposits.—*Institution of Civil Engineers, April* 3.—In the case of the saline deposition, which accumulates in boilers during sea-voyages, it was mentioned as the usual practice merely to blow off a portion of water from the boiler, according as it becomes saturated. In short voyages of three or four days, this is found sufficient for the purpose; but for vessels crossing the Atlantic, or on other long voyages, a more efficient plan has been resorted to, by attaching an apparatus to the engine which pumps out brine from the bottom of the boiler, at the same time throwing in a quantity of clear water equal to what is abstracted. The degree of saturation is indicated by means of an attached thermometer: 218 degrees Fahr. being the boiling point of clean sea water in a steam engine boiler, a range is allowed from that to 227 degrees, which marks the limit of saturation admissible for a steam boiler to be worked with safety.—[Ath.]



A Machine in which all the Mechanical Powers are united.—The preceding figure represents a machine in which all the simple mechanical powers are combined.

It consists of a frame A B C D, fastened upon the stand O *o* by the nut *o*, and kept together by the pillars V W and B *q*. The piece E F is first fitted to the frame, having vanes, E F, which may be either moved by the wind, or by a cord fastened at F. This part represents the lever, whose fulcrum is G. A perpendicular axis G A is joined to this lever, and carries the endless screw H, which may be considered as a wedge. This endless screw works in the teeth of the wheel K, which is the wheel and axle; and when K is turned round, it winds upon the axle I L the cord L M, which, passing round the tackle of pulleys M N, raises the weight P. In order to include the inclined plane in this combination, we must add the plane R Q *r q*, and make it rest on the ground at Q R, and on the pillar B *q* at *q r*. When the weight P is placed on this plane, the power will be farther increased in the ratio of Q T to T S. The power gained by this combination will be found, by comparing the space described by the point F with the height through which the weight rises in any determinate number of revolutions of F.

Decimal Fractions.—We now proceed to explain the species of fractions which are called *decimal*, a word derived from the Latin *decem*, ten. In doing this it will be necessary to enter upon the decimal system generally, and to point out the features which distinguish our arithmetic from that of ancient times. The Greeks and Romans reckoned as we do, by tens; that is to say, having given names to the first ten numbers, they made these names serve to reckon all numbers as far as ten tens, or one hundred, for which a new name was introduced; with this they proceeded as far as ten hundreds, or one thousand, where again a new name was adopted. In the symbols by which they represented numbers, they were not fortunate; and the Roman method especially, which is often used amongst us, is so clumsy as to make it no matter of wonder why that people never cultivated arithmetic with success. Our method came originally from India through the Moors, who brought it into

Spain. It enables us to represent all numbers by means of ten symbols, one denoting nothing, and the rest standing for the first nine numbers. The value of a figure depends not only upon the number which it represents, when it stands alone, but also upon the place or column in which it is found. Thus, in 2222 yards, the two on the right hand stands for two yards only; the next to it for 2 tens of yards, or twice ten yards, or twenty yards; the next for two tens of tens of yards, or two hundred yards; the next for two tens of hundreds of yards, or two thousand yards. It is necessary to recall this, which is well known to all our readers, and in which the superiority of the modern system consists, in order to show how simply fractions may be represented by an extension of the same method. In the number 11111, if we proceed from left to right, each unit is the tenth part of the one which preceded it. Thus the first one is ten thousand, the second one thousand, the third one hundred, and so on. The last 1 is simply a unit, which may, introducing fractions, be divided into ten parts, each of which will be one tenth of the unit, and will be represented in the common way by $\frac{1}{10}$. If we would carry on the notation just explained, in the case of 11111, we may place one more unit on the right and agree that it shall stand for $\frac{1}{10}$ of the unit. This would give 11111 1, in which the separation is made to avoid confounding this, which is eleven thousand one hundred and eleven yards and one-tenth of a yard, with 111111, which is one hundred and eleven thousand one hundred and eleven yards. In the same way in 11111 1111, the first 1 after the unit's place, or the first which is separated from the rest, stands for one-tenth of a yard, the second for one-tenth of a tenth, or one-hundredth of a yard, the third for a tenth of a hundred of a yard or one-thousandth of a yard, and the fourth for one-tenth of a thousandth, or one-ten-thousandth part of a yard. Instead of a separation, it is usual to mark a point after the unit's place, and all figures which come before the point are whole yards, pounds, acres, &c., as the case may be, while all which come after the point are fractions of the same. Thus, 12·34 yards stands for 12 yards, 3 tenths of a yard, and 4 hundredths of a yard; ·768 stands for 7 tenths, 6 hundredths and 8 thousandths. The cipher is used in the same way as in whole numbers, viz. to keep each number in its proper place. Thus one-hundredth is distinguished from one-tenth by writing the first ·01, and the second ·1, since the second column on the right of the point is appropriated to hundredths, and the first to tenths. Thus ·308 is three tenths and eight *thousandths;* ·0308 is 3 hundredths and 8 ten thousandth parts.

These fractions may be represented in another way. Thus, ·123, which is one-tenth, 2 hundredths, and 3 thousandths, is also 123 thousandths, or one hundred and twenty-three parts out of a thousand. For if we divide the unit into 1000 parts, one-tenth is 100 of these parts, one hundredth is 10, and two hundredths are 20 of these parts, and three thousandths are three of these parts. Similarly ·76 is either 7 tenths and 6 hundredths, or 76 hundredths. The rule is: To write a decimal fraction in the common way, let the numerator be the number which follows the point, throwing away cyphers from the beginning if necessary; let the denominator be unity followed by as many ciphers as there are places of figures after the point. By the same rule a number and decimal fraction may be converted into one common fraction, the numerator being formed by throwing away the decimal point. Thus 7·12 is 7 $\frac{12}{100}$ or $\frac{712}{100}$.

The decimal point is always understood as coming after the unit's place, even when there are no fractions. Thus 16 is 16· or 16·000. And any number of ciphers may be placed after a decimal without altering its value. Thus ·4 and ·40 are the same, the first being 4 parts out of ten, and the second also 4 parts out of ten, or which is the same thing, 40 parts out of one hundred. No fraction can be converted into a decimal of *exactly* the same value, unless its denominator be either 5 or 2, or a product of some number of fives and twos, such as 250, which is the product of 5, 5, 5, and 2. For the changing a common into a decimal fraction is the finding a second fraction, equal in value to the first, and whose denominator shall be one of the series of *decimal* numbers, 10, 100, 1000, &c. There is only one way of altering the terms of a fraction without altering its value, viz. by multiplying or dividing both numerator and denominator by the same number. It will easily be found by experiment, and it is proved in books of algebra, that a *decimal* number, that is, a unit followed by ciphers, is not divisible by any number except it be either 2, 5, or a product of twos and fives. Hence it is impossible that a multiplier can be found for 7, for example, which shall make the product a decimal number

for i so, since the product is always divisible by the multiplicand, there would be a decimal number divisible by 7, which is impossible.

Hence there is no decimal fraction exactly equal to $\frac{1}{7}$, or $\frac{1}{9}$, or $\frac{1}{13}$, and so on. Nevertheless, a decimal fraction can be found as near as we please to any fraction whatever; that is, if we take $\frac{2}{13}$, and take any fraction as small as we please, for example, $\frac{1}{100000}$ or ·00001, we can find a decimal fraction which shall not differ from $\frac{2}{13}$ by so much as ·00001; and if we please, we can come still nearer than that small difference. Suppose it is required to find a decimal fraction which shall not differ from $\frac{2}{13}$ by so much as $\frac{1}{1000}$ or ·001. Multiply the numerator and denominator by 1000, which gives $\frac{2000}{13000}$. The numerator 2000, divided by 13, gives the quotient 153 and the remainder 11; so that both 2000 diminished by 11, and 2000 increased by two, are divisible by 13, that s, 1989 and 2002 are divisible by 13, and give the quotients 153 and 154. Of the three fractions $\frac{1989}{13000}$ $\frac{2000}{13000}$ and $\frac{2002}{13000}$, which have the same denominator, the first is the least, the third is the greatest, and the second lies between the first and third. But the first and third (dividing both numerator and denominator by 13) are $\frac{153}{1000}$ and $\frac{154}{1000}$ or ·153 and ·154, and the second is the same as $\frac{2}{13}$. The first and third differ from one another by $\frac{1}{1000}$ or ·001; hence the second, which lies between them, does not differ by so much as $\frac{1}{1000}$ from either. We have, therefore, two decimal fractions ·153 and ·154, the first a little less, and the second a little greater, than $\frac{2}{13}$, each within $\frac{1}{1000}$ of $\frac{2}{13}$. The rule derived from this process is—To find a decimal fraction which shall not differ from a common fraction by so much as $\frac{1}{1000}$, &c. annex as many ciphers to the numerator as there are ciphers in 1000, &c., divide by the denominator, and cut off by the decimal point from the quotient as many places as there were cyphers in 1000, &c., completing the number, if necessary, by adding cyphers to the left, and taking no account of the remainder. Thus $\frac{365}{18}$ is within $\frac{1}{1000000}$ of 20·277777.

The rules for addition, subtraction, multiplication and division, of decimal fractions, are very similar to those in whole numbers. In addition and subtraction the decimal points are to be placed under one another, which will bring units under units, tens under tens, tenths under tenths, &c. The process is then precisely the same as in whole numbers, the decimal point in the result being placed under the other points. In multiplication we must proceed to multiply as if there were no decimal points, and afterwards make as many decimal places in the result as were in both the multiplier and multiplicand. For the product of ·238 and ·112 or $\frac{238}{1000}$ and $\frac{112}{1000}$ is, by the common rule, $\frac{26656}{1000000}$: and as one decimal number is multiplied by another by forming a third decimal number, which shall have as many ciphers as both the former ones together, and since the number of ciphers in the denominator of a decimal fraction expressed in the common way is the number of places which it will have when the point is substituted for the denominator, the reason of the rule is evident. The product obtained above is ·026656 by the rule, one cipher being necessary to make up six places. It is moreover evident that $\frac{26656}{1000000}$ is less than ·1 or $\frac{1}{10}$, the latter being $\frac{100000}{1000000}$.

The rule for division of one decimal by another, as given in many books of arithmetic, is likely to mislead the student in various cases. From the following principles a rule may be drawn which will apply to every possible case. If there be no decimals either in the dividend or divisor, the rule has been already explained. Thus the division of 17 by 6 is the same thing as the reduction of $\frac{17}{6}$ to a decimal fraction, since the sixth part of unity repeated 17 times is the sixth part of 17. Again, we must observe that when two fractions have the same denominator, their quotient is the same as the quotient of their numerators. Thus $\frac{2}{3}$ is contained in $\frac{17}{3}$, just as 2 is contained in 17. By the rule, $\frac{17}{3}$ divided by $\frac{2}{3}$ gives $\frac{51}{6}$, which having the numerator and denominator both divisible by 3, is the same as $\frac{17}{2}$. If then two fractions have the same denominator, the denominator may be rejected in division, and the one numerator divided by the other. Two decimal fractions may be reduced to the same denominator by annexing ciphers to the right of that which has the fewest number of places, so as to make the same number of places in both. For we have shown that a decimal is not altered by annexing ciphers on the right, and we know that two decimals which have the same number of places have the same denominator, viz. unity followed by as many ciphers as there are places. If then, we have to divide 42·1 by ·0017 we begin by annexing three ciphers to 42·1, which gives 42·1000 and ·0017, which having the same denominator, we retain only the numerators, which

are 421000 and 17. It only remains to reduce $\frac{421000}{17}$ to a decimal fraction, to do which we annex as many *more* ciphers to the numerator as we want decimal places. Thus, if we want 4 places, we divide 421000,0000 by 17, the quotient of which, taking no account of the remainder, is the answer required. Again, to divide 4·03812 by 1161·7, we annex four ciphers to the latter, and reject the denominators, which gives 403812 and 116170000. We then reduce $\frac{403812}{116170000}$ to a decimal fraction; but in doing this, the rule may be somewhat simplified, since the annexing a cipher to the numerator is the same thing as taking one away from the denominator: thus $\frac{4038120}{116170000}$ is the same fraction as $\frac{403812}{11617000}$. If therefore we want five places of decimals, instead of annexing five ciphers to the numerator, we take away the four from the denominator and annex one to the numerator, and divide 4038120 by 11617, the quotient of which is 347; and as there are to be 5 decimal places, the result is ·00347. Similarly to divide 42 by ·007, we divide 42000 by 7, which gives 6000.

When any decimals are thrown away from a result, it is more correct to increase the last remaining figure by 1, if the first figure thrown away were 5 or upwards. Thus, if out of ·13885, we retain only four places, we write it ·1389, this being nearer to ·13885 than ·1388. If we retain 3 places only, we write ·139. On the same principle, if we had to mention 278 in round numbers, we should rather call it 300 than 200.

Bias of the Mind respecting the Future.—The common bias of the mind undoubtedly is, (such is the benevolent appointment of Providence,) to think favorably of the future, to overvalue the chances of possible good, and to underrate the risk of possible evil; and in the case of some fortunate individuals, this disposition remains after a thousand disappointments. To what this bias of our nature is owing it is not material for us to inquire; the fact is certain, and it is an important one to our happiness. It supports us under the real distresses of life, and cheers and animates all our labors; and although it is sometimes apt to produce, in a weak and indolent mind, those deceitful suggestions of ambition and vanity, which lead us to sacrifice the comforts and duties of the present moment to romantic hopes and expectations, yet it must be acknowledged, when connected with habits of activity, and regulated by a solid judgment, to have a favorable effect on the character, by inspiring that ardor and enthusiasm which both prompt to great enterprizes, and are necessary to insure their success. When such a temper is united (as it commonly is) with pleasing notions concerning the order of the universe, and in particular concerning the condition and the prospects of man, it places our happiness in a great measure beyond the power of fortune. While it adds a double relish to every enjoyment, it blunts the edge of all our sufferings; and even when human life presents to us no object on which our hopes can rest, it invites the imagination beyond the dark and troubled horizon which terminates all our earthly prospects, to wander unconfined in the regions of futurity. A man of benevolence, whose mind is enlarged by philosophy, will indulge the same agreeable anticipations with respect to society; will view all the different improvements in arts, in commerce, and in the sciences, as co-operating to promote the union, the happiness, and the virtue of mankind; and, amidst the political disorders resulting from the prejudices and follies of his own times, will look forward with transport to the blessings which are reserved for posterity in a more enlightened age.—[Dugald Stewart.]

Co-operative Laborers.—Many of our readers are no doubt aware that some well-intentioned men have been endeavoring for a long time to effect a great change in society, by establishing a new arrangement, called Co-operation, which assumes that the laborers should be at the same time the capitalists. There can be no sort of objection to this principle, when it is proposed to carry it into action without any prejudice to the existing laws of property; and, no doubt, many of the evils of our social state might be removed, were all persons concerned in the business of production to have a sort of proprietary interest in the commodities produced. The mistake of those who exclusively call themselves co-operatives, is that of assuming that the love of individual property can be got rid of by a very short process of reasoning, and neglecting to avail themselves of the many *practical* modes in which industry might be made more productive than at present, by a union of forces, in which the personal interests of every laborer would be dependent upon the success of the business in which he is engaged. There are many examples of such real co-operation already existing in the world, some

of which we may mention, from time to time. We shall now state a few facts regarding the mode of navigating vessels in the Mediterranean, by men having a common proprietorship.

With the exception of some large ships that belong to wealthy merchants of Hydra, Spezzia, &c., chiefly employed in the corn trade in the Black Sea, nearly all the Greek vessels are navigated by men taking fixed shares of the profits or freights obtained. The captain has more shares than the common men, and so has the second in command, who is generally intrusted with the *contabiliti* or accounts. When the vessel is small and the voyage short, it is sometimes the custom for each individual to lay in his own wine and provisions; but the general practice is for the captain or the second to purchase a stock for the whole, the amount of which is put on the debtor side of the account, and at the end of the voyage subtracted from the gains made: the distribution being fairly conducted during the voyage. The same system is found nearly all over the Mediterranean. The Neapolitans, the Sicilians, and the Genoese, rarely navigate in any other way.

The Italian captain has sometimes a share in the vessel, which proportionately increases his share in the profits. He is occasionally, though rarely, except when the craft is very small, the sole proprietor; but even in the latter case the men are engaged just in the same way. A small vessel called a "Bovo," or a "Paranza," of not more than sixty tons, not worth £150, is often held by as many as six or ten different proprietors.

From the town of La Torre dell' Annunziata, in the Bay of Naples, there is a coral fishery carried on. They sometimes fish about Sardinia, but the great place is on the coast of Africa, near Bona. They leave Naples in little fleets of four, six, or eight, open boats, and availing themselves of the fine summer season, venture right across the Mediterranean. These boats are navigated on the same principle. Sometimes the boat is the united property of the men in it, who give one of their number a larger share of the profit on account of his superior nautical skill or experience in the fishery. The abstemious manner in which these Mediterranean sailors, (Italians, Greeks, Sclavonians, Spaniards, Provençales, and all,) live is astonishing. Bread, *legumes*, olives, salt-fish, a little maccaroni, are their sole support. They scarcely ever taste meat.

A large portion of the shore boats that ply about the harbor at Smyrna are manned by Sclavonians, from about the Bocca di Cattaro, and by our subjects the Maltese. On an average each boat has two men; to them the boat belongs, and they divide their profits every evening. When an old boat is to be repaired, or a new one bought, the two partners club together; or sometimes, in the case of the purchase of a new boat, a third party is admitted, who receives a given share of what the boat makes.

In the Italian ships such of the sailors as have a little money are allowed to invest it in goods, and to carry these goods with them, disposing of them as they choose at the ports they touch at or are bound to. This is called the "*Paccotiglia.*" Intelligent and prudent sailors often make more money this way than by their shares in freight.

Those who have attended to this system state that the sailors are deficient in discipline; but they also observe that, in proportion as the men are of a steady and intelligent character, this evil vanishes. It is no doubt true that *mutual* interests can only be properly understood by men far advanced in civilization. Ignorance is always selfish.

On the Eye—Duration of Impressions. [From Dr. Arnott's Elements of Physic.]

Any impressions of light made upon the retina lasts for about the sixth of a second. Hence, when the burning end of a stick is made to describe any line or curve, its path becomes a line of light; and if it revolve in a circle six times in a second, that circle will appear to the eye a complete circle of fire. The polished end of an elastic wire, fixed by its other end in a block of wood, being made to vibrate, similarly forms a line or curve of light. A harp-string, while vibrating as it sounds, appears like a flat riband. Lightning or other meteor, darting across the sky, although, in fact, but a moving luminous point, is generally thought of as a long line of light: the term forked-lightning has reference to this prejudice. The same remark applies, in a degree, to a sky-rocket in its rapid ascent. Two or more colors painted separately on the rim of a wheel which is made to turn rapidly, appear to the eye to be as completely united as if they were really mixed: it has been already explained how patches of the various colors of the rainbow mixed in this way form white light. If on one side of a card a little bird be painted, and on a corresponding part of the other side a cage, then, on making

the card turn rapidly by twisting between the fingers two threads fixed to its opposite edges, the little bird will appear to be imprisoned in the cage: or, again, if a pensive Juliet sitting in her bower occupy one side of the card, and a longing Romeo the other, by the magic turn of the threads the passionate lovers may instantly be brought together. Dr. Paris displayed taste and an amiable ingenuity, in designing this toy with great variety of subjects.

A certain intensity of light is necessary to distinct vision, but the degree varies with the previous state of the organ. A person passing from the bright day into a shaded room, for a time may fancy himself in total darkness; and to persons sitting in the room and become accustomed to the less light so as to see well with it, he will appear to be almost blind. The dawn of morning after the darkness of night appears much brighter than an equal degree of light in the evening. When, as the night falls, our lamps or candles are first introduced, the glare is often for a time offensive: and the same feeling is still stronger on opening, in the morning, bedroom window shutters or close-drawn curtains. After the repose of night, the sensibility of the eye is such that the globules of blood in the capillary vessels of the retina produce the impression on it of little globes of light, crossing among each other as the tortuous vessels do. To a prisoner, after a long confinement in a dark dungeon, the light of the sun is almost insupportable. And a dungeon, which to common eyes is utterly dark, still to its long-held inmate has ceased to be so. There are various instances in the records of the barbarous ages, of prisoners confined for years in utter darkness, who at last could see and make companions of the mice which frequented their cells. The darkness of a total eclipse after bright sunshine appears much more deep than that of midnight, because of the sudden contrast. The long polar night of months ceases to appear very dark to the polar inhabitants. If an eye be directed for a time to a black wafer laid on a sheet of white paper, and afterwards to another part of the sheet, a portion of the paper of the size of the wafer will appear brilliantly illuminated; for the ordinary degree of light from it appears intense to the part of the eye lately receiving almost none. An eye directed long and intensely upon any minute object—as when a sailor watches a speck in the distant horizon, supposed to be a ship, or when a hunter on the brown heath keeps his eye fixed on some game nearly of the color of the heath, or when an astronomer gazes long at a little star—has the sensibility of its centre at last exhausted, and ceases to perceive the object; but on directing the axis of the eye a little to one side of the object, so that an image may be formed only *near* the centre, the object may be again perceived, and the centre in the mean time enjoying repose will recover its power.

But the most extraordinary fact connected with the sensibility of the retina is, that if part of it be strongly exercised by looking for a time at an object of any bright color, on then turning the eye away, or altogether shutting it, an impression or spectrum will remain of the same form as the object lately contemplated, but of a perfectly different color. Thus, if an eye be directed for a time to a red wafer laid on white paper, and be then shut or turned to another part of the paper, a beautifully bright green wafer will be seen; and *vice versa*, a green wafer will produce a red spectrum, an orange wafer will similarly produce a blue spectrum, a yellow one a violet spectrum, &c.; and a cluster of wafers will produce a similar cluster of opposite colors. If the hand be then held over the eyelids to darken the eyes and prevent entirely the approach of light, the spectrum of the bright parts will be luminous, surrounded by a dark ground, and when the hand is again removed the contrary will be true. Again, if the eye be in a degree fatigued by looking at the setting sun, or even at a window with a bright sky beyond it, or at any very bright object, on then shutting it, the lately contemplated forms will be perceived, first of one vivid color, and then of another, until perhaps all the primary colors have passed in review. These extraordinary facts prove that the sensation of light and color, although excitable by light, is also producible without it. This truth gave occasion to Darwin's ingenious theory, that the sensation of any particular color, of red for instance, is dependent upon a certain state of contraction of the minute fibres of the retina, as the sensation of a particular tone depends on a certain frequency of vibration of some part of the ear, and that the fibres, when fatigued in that condition, seek relief, when at liberty, by throwing themselves in an opposite state—as a man, whose back is fatigued by bending forward, relieves himself not by merely standing erect, but by bending the spine backwards—which new condition, whether produced by light or by

any other cause, gives the sensation of green. He applied his explanation similarly to all other cases of color. It is remarkable that the colors which thus appear opposite to each other in kind are those which, when the solar spectrum produced by a prism, as described a few pages back, is painted round a wheel or circle, are opposite to each other in place.

There are persons who, although having distinct perceptions of form and of light and shade, have not the power of distinguishing colors. It is common for such persons to deem pink and pea-green (naturally opposites) the same color, and therefore not to distinguish difference of color in a red berry and the leaves around it. A man with this defect, trusting to his own judgment, might, without knowing it, dress himself like a parrot.

Largest Column in the World.—The following is an account of the monument erected by the Emperor Nicholas to the memory of his brother, the late Emperor Alexander. The shaft was placed on its pedestal on St. Alexander Nefskey's day, August 30, (O. S.) 1832, in the presence of the imperial family, nobility, citizens, and strangers. The day was remarkably fine, and an immense concourse—an almost countless multitude—assembled to witness the operation, in the large square in front of the Hermitage, or winter palace of the Emperor. The monument is of red granite. The pedestal, which is square, is 40 feet high; the shaft is round and in one piece; it is 85 feet high and 12 feet in diameter at the top; it weighs 600 tons. The column supports a colossal bronze statue, representing an angel holding a cross. The statue, with its pedestal, including the capital of the column, is 35 feet high, and the height of the monument from the ground to the top of the statue is 165 feet. The stone was brought from Finland, (from the same quarry where the celebrated pillars of the castle and church, polished like marble, were procured,) and transported to St. Petersburgh in a ship built for the purpose, towed by a steamboat. The inclined plane on which the shaft was rolled from the river Neva to its present site, contained a forest of wood, and cost in that country, where it is so cheap, a million of rubles, or $200,000. The column was raised and safely placed on its pedestal by means of 60 capstans, manned by 2500 veterans, who had served with Alexander in his most glorious campaigns. Each of them wore badges of honor. The preparations for the stupendous undertaking were so complete, that not the slightest accident occurred; and during the operation of raising the shaft, not a whisper nor a word was heard throughout the vast multitude who witnessed the scene.

Effects of Climate and Passions on the Mind.—Climate, by its influence upon the body, produces endless diversities of mind. Compare the timid, indolent, vivacious, and irritable inhabitant of the line, with the phlegmatic and stupid Greenlander. Every man knows how the state of his mind is modified by different periods of the day, changes in the weather, and the seasons.* He who attempts mental effort during a fit of indigestion will cease to wonder that Plato located the soul in the stomach. A few drops of water upon the face, or a feather burnt under the nostril of one in a swoon, awakens the mind from its deep sleep of unconsciousness. A slight impression made upon a nerve often breaks the chain of thought, and the mind tosses in tumult. Let a peculiar vibration quiver upon the nerve of hearing, and a tide of wild emotion rushes over the soul.

> "By turns they feel the glowing mind
> Disturbed, delighted, raised, refined."

Strike up the Marseilles in the streets of Paris, and you lash the populace into fury. Sing the Ranz des Vaches to the Swiss soldiers, and they gush into tears. The man who can think with a gnat in his eye, or reason while the nerve of a tooth is twinging, or when his stomach is nauseated, or when his lungs are oppressed and laboring,—he who can give wing to his imagination when shivering with cold, or fainting with heat, or worn down with toil,—can claim exemption from the common lot of humanity. In different periods of life, the mind waxes and wanes with the body; in youth, cheerful, full of daring, quick to see, and keen to feel; in old age, desponding, timid, perception dim, and emotion languid. When the blood circulates with unusual energy, the coward rises into a hero; when it creeps feebly, the hero sinks into a coward.

The effects produced by different states of the mind upon the body are equally sudden and powerful. Plato used to say, that "all the diseases of the body proceed from

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* It is a well known fact, that almost all the suicides which take place in London and Paris are committed during the *rainy season*.

the soul." The expression of the countenance *is mind visible.* *Bad news* weakens the action of the heart, oppresses the lungs, destroys appetite, stops digestion, and partially suspends all the functions of the system. An emotion of shame flushes the face; fear blanches it; joy illuminates it, and an instant thrill electrifies a million nerves. Surprize spurs the pulse into a gallop. Delirium infuses giant energy. Volition commands, and hundreds of muscles spring to execute. Powerful emotion often kills the body at a stroke. Chilo, Diagoras, and Sophocles, died of joy at the Elean games. The news of a defeat killed Philip V. One of the popes died of an emotion of the ludicrous, on seeing his pet monkey robed in pontificals, and occupying the chair of state. Muley Moluck was carried upon the field of battle in the last stages of an incurable disease. Upon seeing his army give way, he leaped from the litter, rallied his panic stricken troops, rolled back the tide of battle, shouted victory, and died. The door-keeper of Congress expired upon hearing of the surrender of Cornwallis. Eminent public speakers have often died, either in the midst of an impassioned burst of eloquence, or when the deep emotion that produced it had suddenly subsided. The late Mr. Pinckney, of Baltimore, Mr. Emmet, of New-York, and the Hon. Ezekiel Webster, of New-Hampshire, are recent instances. Lagrave, the young Parisian, died, a few months since, when he heard that the musical prize for which he had competed was adjudged to another. The recent case of Hills, in New-York, is fresh in the memory of all. He was apprehended for theft, taken before the police, and though in perfect health, mental agony forced the blood from his nostrils. He was carried out, and died.—[Annals of Education.]

Founders of Colleges.—Who ever heard of a liberally educated man who was not the hearty devoted supporter of every judicious common school system? Such an anomaly our country has not yet produced. Our most illustrious patriots and sages have been the founders of colleges, and apostles in the cause of universal education.

It is no uncommon thing, in our country, for men of considerable influence to boast that they have never seen the inside of a college—that, like Franklin and Washington, they have advanced in knowledge and reputation by their own unassisted efforts; and consequently, that colleges are good for nothing, or at best fitted only for the training of drones and blockheads. Now, besides the extreme modesty of recording their own names upon the same tablets with Franklin and Washington, they might be reminded that those truly great men never uttered such a boast, and never decried such institutions. Franklin was the father of the University of Pennsylvania, and Washington endowed a college in his native state. No man, therefore, will ever give any very convincing evidence that he resembles Franklin or Washington, by a supercilious affectation of contempt for colleges, or by a narrow, invidious, systematic, malignant hostility towards them.—[President Lindsey on Education.]

Economy.—Every enlightened Christian community, since the creation of the world, has had political and pecuniary prosperity. Commodious churches and school-houses always produce commodious dwellings, well cultivated farms, convenient vehicles and good roads.

Five dollars expended upon infant schools always prevents more poverty and crime than five thousand spent on prisons, courts, and other legal provisions to protect the morals of a community.

Two dollars will provide a year's entertainment and instruction at a Lyceum; from three to ten dollars will furnish one evening's entertainment at a ball.

Commodious Lyceum Buildings have generally paid from one to two hundred per cent. interest on the money they cost.

The expenses of horse-racing in the United States for one year is sufficient to erect an elegant Lyceum in every town and village in the Union.

The interest of the money expended for the Pennsylvania State Prison is sufficient to pay the tuition of ten thousand children at infant schools.

The money annually expended for military trainings in Massachusetts is sufficient to establish and endow a Lyceum Seminary, or self-supporting school, in every county in the State, at thirty thousand dollars each.

Doing Good.—Instead of showing our love to our country by engaging eagerly in the strife of parties, let us choose to signalize it rather by beneficence, and by an exemplary discharge of the duties of private life, under the persuasion that a man, in the final issue of things, will be seen to have been the

best patriot who is the best Christian. He who diffuses the most happiness, and mitigates the most distress, within his own circle, is undoubtedly the best friend to his country and the world, since nothing more is necessary than for all men to imitate his conduct, to make the greatest part of the misery of the world cease in a moment. While the passion, then, of some is to *shine*, of some to *govern*, and of others to *accumulate*, let one great passion alone inflame our breasts, the passion which reason ratifies, which conscience approves, which heaven inspires—that of being and doing good.—[Rob. Hall.]

Mechanical Skill of the Ancient Egyptians.—A paper was read, on the 11th June, 1832, at the French Academy of Sciences, by M. Jomard, which shows, from the hieroglyphic remains found on the Egyptian monuments, that most of the principal mechanical instruments with which we are now acquainted were known to them. In a picture found in the Palace of Carnac, are seen a vessel fixed by means of anchors, and a capstan in connection with it; it is also seen from it that the ancients were acquainted with the vice. It appears to be by means of inclined planes and capstans that they raised the immense blocks of stone of which their great monuments are composed. M. Jomard also proved that they knew the use of the pulley.—[Lond. Mec. Mag.]

Black Colors.—The blackness of bodies is supposed by philosophers to be owing to the luminous rays that fall upon them being in great part absorbed or stifled in their pores; and hence they also receive heat more freely than others. Black marble or tiles, exposed to the sun, become sensibly hotter than white ones. Black paper is kindled by a burning glass much sooner than white, and the difference is strongly marked; a burning glass too weak to have any visible effect at all upon white paper, shall readily kindle the same paper rubbed over with ink; hence black clothes, when wetted, are said to dry faster; black habits, and rooms hung with black, to be warmer; black mould to be a hotter soil for vegetables; and garden walls, painted black, to answer better for ripening of wall fruit than those of lighter colors. It is not, however, to be affirmed, that the like differences obtain in the impressions made by common fire. Black paper held to the fire does not seem to be effected sooner, or in a greater degree, than such as is white. It may be proper to observe also, that the combustibility of the paper may be increased, by impregnating it with substances of themselves not combustible, and which give no color to it. This is the foundation of one of the sympathetic inks, as they are called, made of a strong solution of sal ammoniac in water; which, though colorless when written with on paper, becomes very legible on exposing the paper to the fire—that is, it occasions the parts moistened with it to scorch or burn before the rest of the paper is hurt, to a brown or black.

Steel Engravings.—A Mr. Percy Heath has discovered a mode of re-biting steel plates, by which he can bring up to color those tints which are usually considered incapable of profiting by that process. This method promises to be useful in restoring worn plates, or such as merit to be repaired.—[Athenæum.]

Consumption of Silk.—The quantity of this material used in England alone amounts in each year to more than four millions of pounds weight, for the production of which myriads upon myriads of insects are required. Fourteen thousand millions of animated creatures annually live and die to supply this corner of the world with an article of luxury. If astonishment be excited at this fact, let us extend our view into China, and survey the dense population of its widely spread region, whose inhabitants, from the Emperor on his throne to the peasant in the lowly hut, are indebted for their clothing to the labors of the silkworm. The imagination, fatigued with the flight, is lost and bewildered in contemplating the countless numbers which every year spin their slender threads for the service of man.—[Lardner's Cyclopædia.]

How to tin Nails, Tacks, &c.—First clean the surface of the articles to be tinned from rust or other oxide, by pickling them, or putting them into sulphuric, muriatic, or nitric acid, diluted with water, as usual, and washing them well afterwards in water; then put them into a stone-ware gallon bottle, together with a proportionate quantity of bar or grain tin, and of sal ammoniac: next place this vessel, lying upon its side, over a charcoal fire, made upon a forge hearth, and keep turning it round, and frequently shaking it, to distribute the tin uniformly over the surface of the articles to be tinned; lastly, throw the articles into water, to wash away all the remains of the sal ammoniac, and fi-

nally dry them in saw dust made warm. The great merit of this process consists in the employment of the stone-ware vessel, which not only prevents the dissipation of the sal ammoniac in fumes, but also gives up the whole of the tin to the articles to be tinned, which would not be the case were a metallic vessel to be used.

To imitate Leaf-Gilding on Leather.—Take some calf-skins which have been softened in water, and beat on a stone to their greatest extent whilst wet; rub the grain side of the leather with a piece of size, whilst in a state of gelly; and before this size dries, lay on a number of silver leaves. When covered with the silver leaf, the skins are to be dried till they are in a proper state for burnishing, which is performed by a piece of large flint fixed in a wooden handle; the appearance of gold is then given to the silvered surface by covering it with a yellow varnish, or lacker, which is composed of four parts of white resin, the same quantity of common resin, two parts of gum sandarac, and two parts of aloes. These ingredients are to be melted together in an earthen vessel, and after being well mixed by stirring, twenty parts of linseed oil is to be poured in; and when the composition is sufficiently boiled to make a perfect union, and to have the consistence of a syrup, half an ounce of red lead is to be added, and the liquid passed through a flannel bag. To apply this varnish, the skins must be spread out upon a board, fastened down by nails, and exposed to the rays of the sun, and when thus warmed, the white of an egg is to be spread over the silver. After it is dry the varnish is laid on, which will dry in a few hours, and is very durable.

Useful Discovery.—A machine has been invented and put in operation, in Philadelphia, for napping hats by steam. The editor of the Philadelphia Inquirer recently witnessed the performance of this machine in a hat manufactory, and speaks in high terms of its capabilities. The beauty and superiority of the work are at once admitted by all who have examined it. It is not stated whether or not the process is more rapid than by the old method; but it is held to turn out a much better article, as the napping process requires very hot water, and steam applied to the same purpose may be many degrees hotter than boiling water. The invention is thought to be a very useful one.

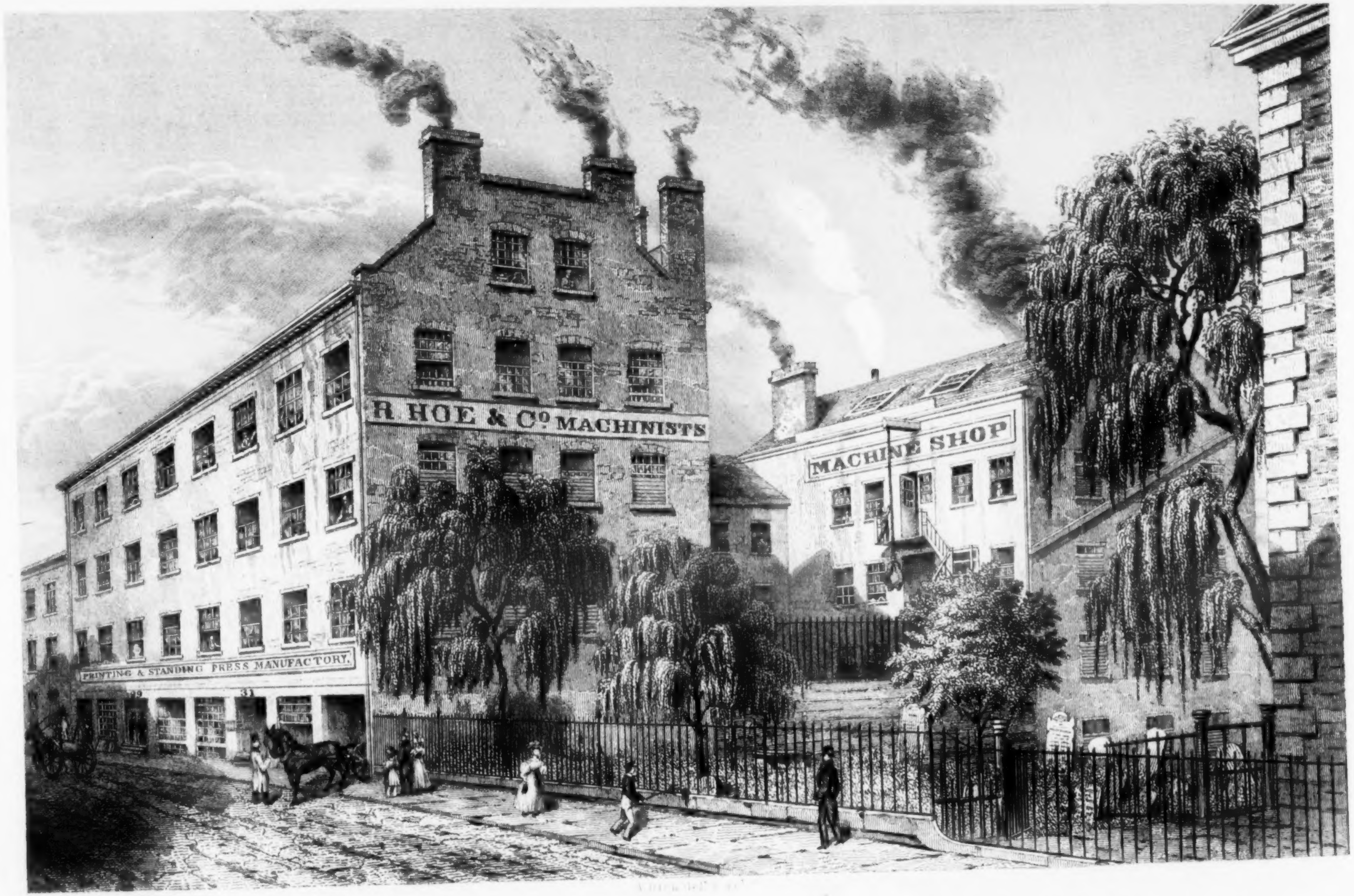
Manufacture of Glass.—In the whole circle of manufactures there is not any thing more curious than the one that is depicted in the above engraving.* Materials, which appear of themselves but little fitted for any useful purpose, are blended together so as to form compounds of a new and entirely distinct character. Indeed, an uninitiated person looking at the sand, lead, and pearl-ashes, as they are prepared for the glass houses, would consider that nothing less than the wand of the enchanter could accomplish their change into a hard and crystalline body.

The ingredients usually employed in the manufacture of glass, with their relative proportions, may be thus briefly described:

120	parts of	well washed white sand
40	"	purified pearl-ashes
35	"	litharge
13	"	nitre
1	"	black oxide of manganese.

When these materials are collected and properly proportioned, they receive a certain amount of calcination prior to their being placed in the melting pot. This operation is called *fritting*, and is performed either in small furnaces adjoining to the proper glass furnace, and heated by the same fuel, after its principal force has been expended on the glass pots, or else in ovens constructed for the purpose. The use of this preparatory process is to discharge all moisture from the ingredients, and to drive off the carbonic gas. This operation is performed gradually, and carried to the point of semi-vitrification. When the materials are sufficiently "fritted," they are thrown with clean iron shovels, through the side opening of the furnace, into the glass-pots, the fire having been previously raised to its greatest intensity. When filled, the opening is closed with wet clay, excepting a small hole for examining the interior of the furnace. The mass soon begins to heave, and exhibit a mass of liquid grandeur, like the waves of the ocean on fire. During this process, samples for examination are frequently brought out by the aid of an iron rod, and the glass becomes beautifully clear and transparent. The glass may now be considered as completely made, but it requires some time to cool down to the requisite working temperature. It should be just soft enough to yield with ease to any external impression, even to the force of the breath, when impelled against the glowing

* We think this description may be sufficiently understood by our readers without the engraving.



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mass, and in that state it may be bent into any required form. Such, indeed, is its tenacity, that it may be rapidly drawn into a solid string, and wound on a reel, many miles in length. Having thus brought the glass to a state fit for what is technically called "blowing," we may introduce our readers into the workshop itself, which will be best done by the aid of a graphic illustration, and the engraved view at the head of this article will admirably answer the purpose. In the present season of the year the temperature of the blowing-house would shame the hottest portions of the torrid zone, and while we now write, we are laboring under the enervating effects of a visit, many hours back, when the thermometer stood at 140 degrees.

The workmen who are represented in the engraving are each engaged in one of the operations essential to the manufacture of a common drinking glass. For this purpose the operator takes a hollow tube, about four feet long, called a blowing iron, and dipping it into the melting-pot, turns it round till a portion of the glass adheres to the surface. He then holds it near the ground, so that the mass is extended by its own weight, and blows strongly into the tube. The breath penetrating the red hot mass enlarges it, and it becomes an elongated sphere of the requisite dimensions. To separate this globe from the iron tube, an assistant dips the end of a solid rod into the glass-pot, and bringing out at its extremity some of the melted glass, thrusts it immediately against the globe at the part directly opposite the neck, so that it may be firmly united. The workman then wets a small piece of iron with his mouth, and lays it on the neck of the globe, and it immediately cracks off, leaving the globe open at the neck. This is again introduced into the fire by the new bar of iron, and afterwards rounded on the rails of a sort of arm-chair. In order to detach the foot from the iron, moisture is again applied, and it drops off. There is a final process called *annealling*, which consists in raising the temperature in a separate oven, and afterwards allowing the glass to cool gradually; it is less likely to break.

Pliny attributes the invention of glass entirely to chance, and relates that it was first made in Syria by some mariners, who were driven on shore on the banks of the river Belus; and who having occasion to make large fires on the sands, burnt the *kali* which abounded on that shore; and that the alkali of the plant uniting with a portion of the sand on which the fire stood, produced the first stream of melted glass that had ever been observed.—[People's Magazine.]

Messrs. Hoe & Co.'s Manufactory.—This extensive establishment, which gives constant employment to upwards of one hundred mechanics, is situated in Gold street. A correct view of the exterior will be found in a steel plate engraving which accompanies this number; of the interior we shall endeavor to give a short description, commencing with the basement of the back shop, denominated in the engraving the machine-shop, in which there is a powerful steam-engine, which by means of shafts convey the power into every work-shop on the premises.

On the first floor are several engines, or slide lathes, which are used for turning, boring, screw-cutting, and a variety of other purposes. In this room are grind-stones and polishing-wheels, for finishing saws and other purposes, and two large lathes used for turning beds and plattens for presses or other flat surfaces.

The second story is occupied by artizans engaged in the construction of single Napier presses, as improved by Mr. Newton, one of the proprietors.

The third story is used as a printers' joiner's shop, in which are several labor-saving machines, one circular sawing machine, which, when in operation, performs 3,000 evolutions per minute, and a boring machine that performs 4,000 evolutions in the same period.

In the building connecting the front and rear shops is a room containing a machine for cutting the teeth of wheels, &c. The plate which forms the register to the machine is so constructed that it can with accuracy be placed so as to cut 40,000 different sizes.

In the cellar and the first story of the front shop are constructed Smith's patent printing presses, which are so much in request by almost all the printers in the Union. Also, a press used for pressing paper; rollers for callenders, embossing machines, &c., of 300 tons pressure; and a machine for bending iron used for cylinders and other purposes.

In the third story are constructed printing machines with double cylinders; and in the rooms above that, are patterns and models of machinery constructed in this country and in Europe.

Independent of the buildings shown in the engraving, Messrs. Hoe & Co. occupy large premises in Eden's Alley, nearly opposite, in the same street. In that department they have a large furnace for hardening saws; here also is their forging shop, and their manufactory for finishing carpenters' squares, bevels, trowels, circular and hand saws, &c. &c. But as our limits will not permit us to enter into a detailed description of the various tools and machines manufactured in this establishment, we shall subjoin their list of articles made on the premises—it is as follows:

Machine presses, double and single cylinder, for newspapers or book-work; Smith printing presses; copperplate and lithographic presses; copying and seal presses; drop, piercing, and transferring presses; hydraulic and fly presses; standing, cotton, and tobacco presses; bookbinders' and saddlers' presses; bookbinders' shears, ploughs and knives, pressboards, rolls, fillets, sewing benches, &c.; ruling machines; chases and imposing stones; type cases and stands; composing sticks, galleys, and slices; patent stereotype blocks; brass rule of every description; buckskin and composition rollers; moulds for casting rollers; printing ink of every quality; types of every description; screws for paper-makers, for cotton, tobacco, coining, and standing presses, &c.; callenders and embossing machines; silver-platers' mills and rollers; dividing engines; large and small lathes; mill gearing and mill work in general. Also, every variety of saws—cast steel mill, pit, and cross-cut saws; hand, pannel, sash and tenon saws; veneering, table, and compass saws; wood-cutters' and felloe, or turning saws; circular saws, in whole plates or in segments; and gin saws. Doctors, or calico printers' webs, of steel or composition; straw, hay, leather dressers' and saddlers' knives; squares, bevels, trowels, &c. &c.

The punctuality, liberality, and well known business manner in which this establishment is conducted, has insured the proprietors a very large share of patronage, and, we must add, it is not misplaced. Such of our ingenious mechanics, and especially those who reside at a distance, who should visit this city, will pass a pleasant hour in going over this establishment; and that pleasure will be considerably enhanced by the truly affable manners of the principals, who will accompany them and point out every thing deserving notice.

Library of Useful Knowledge, published by the "Society for the Diffusion of Useful Knowledge," London, in numbers of pp. 32, by Baldwin & Co. New-York, W. Jackson, Maiden lane.

We hail most cordially the reprint in this city of this useful and interesting series of books, because it places within the reach of all, scientific and good practical and entertaining knowledge. The contents of the whole series are so varied and so excellent, that it is with some difficulty that we have been enabled to decide upon what to extract for our present purpose. From the life of Sir Isaac Newton the following account of his first notions of his system of Philosophy will be perused with interest:

"Voltaire, in his 'Elements of Philosophy,' says that Mrs. Conduit, Newton's niece, attested the fact.

"One day, as he was sitting under an apple tree, (which is still shown,) an apple fell before him; and this incident awakening, perhaps, in his mind, the ideas of uniform and accelerated motion, which he had been employing in his method of fluxions, induced him to reflect on the nature of that remarkable power which urges all bodies to the centre of the earth; which precipitates them towards it with a continually accelerated velocity; and which continues to act without any sensible diminution at the tops of the highest towers, and on the summits of the loftiest mountains. A new idea darted across his mind. 'Why,' he asked himself, 'may not this power extend to the moon, and then what more would be necessary to retain her in her orbit about the earth?' This was but a conjecture; and yet what boldness of thought did it not require to form and deduce it from so trifling an accident! Newton, we may well imagine, applied himself with all his energy to ascertain the truth of the hypothesis. He considered that if the moon were really retained about the earth by terrestrial gravity, the planets, which move round the sun, ought similarly to be retained in their orbits by their gravity towards that body.* Now, if such a force exists, its constancy or variability, as well as its energy at different distances from the centre, ought to

* Newton afterwards showed the truth of his result, by deducing it from a law observed by Kepler, in the movement of all the planets, which consists in the description of areas proportional to the times, by the radius vector drawn from each planet to the sun; but he did not know how to make use of this law till he had discovered the means of calculating the motion in an elliptic orbit; that is, about the end of the year 1679.

manifest itself in the different velocity of the motion in the orbit; and consequently, its law ought to be deducible from a comparison of these motions. Now, in fact, a remarkable relation does exist between them, which Kepler had previously found out by observation, namely, that the squares of the times of revolution of the different planets are proportional to the cubes of their distances from the sun. Setting out with this law, Newton found, by calculation, that the force of solar gravity decreases proportionally to the square of the distance; and it is to be observed that he could not have arrived at this result without having discovered the means of determining from the velocity of a body in its orbit, and the radius of the orbit supposed to be circular, the effort with which it tends to recede from the centre; because it is this effort that determines the intensity of the gravity, (to which, in fact, the effort is equal.) It is precisely on this reasoning, that the beautiful theorems on centrifugal force, published six years afterwards by Huygens, are founded; whence it is plain that Newton himself must necessarily have been acquainted with these very theorems. Having thus determined the law of the gravity of the planets towards the sun, he forthwith endeavored to apply it to the moon; that is to say, to determine the velocity of her movement round the earth, by means of her distance as determined by astronomers, and the intensity of gravity as shown by the fall of bodies at the earth's surface. To make this calculation, it is necessary to know *exactly* the distance from the surface to the centre of the earth, expressed in parts of the same measure that is used in marking the spaces described, in a given time, by falling bodies at the earth's surface; for their velocity is the first term of comparison that determines the intensity of gravity at this distance from the centre, which we apply afterwards at the distance of the moon by diminishing it proportionally to the square of her distance. It then only remains to be seen, if gravity, when thus diminished, has precisely the degree of energy necessary to counteract the centrifugal force of the moon, caused by the observed motion in her orbit. Unhappily, at this time, there existed no correct measure of the earth's dimensions. Such as were to be met with had been made only for nautical purposes, and were extremely imperfect. Newton, having no other resource but to employ them, found that they gave for the force that retains the moon in her orbit, a value greater by one-sixth than that which results from her *observed* circular velocity. This difference, which would, doubtless, to any other person, have appeared very small, seemed, to his cautious mind, a proof sufficiently decisive against the bold conjecture which he had formed. He imagined that some unknown cause, analogous, perhaps, to the vortices of Descartes,* modified, in the case of the moon, the generel law of gravity indicated by the movement of the planets. He did not, however, on this account, wholly abandon his leading notion, but, in conformity with the character of his contemplative mind, he resolved not yet to divulge it, but to wait until study and reflection should reveal to him the unknown cause which modified a law indicated by such strong analogies. This took place in 1665-6. During the latter year, the danger of the plague having ceased, he returned to Cambridge, but he did not disclose his secret to any one, not even to his instructor, Dr. Barrow. It was not till two years afterwards, 1668, that Newton communicated to the latter, who was then engaged in publishing his lectures on Optics, certain theorems relating to the optical properties of curved surfaces, of which Barrow makes very honorable mention in his preface. Newton had now become a colleague of his former tutor, having been admitted master of arts the preceding year. At length, in the same year (1668), an occurrence in the scientific world compelled him to declare himself. Mercator† printed and published, towards the end of this year, a book called *Logarithmotechnia*, in which he had succeeded in obtaining the area of the hyperbola referred to its asymptotes, by expanding its ordinate into an infinite series; this he did *by means of common divison*, as Wallace had done in the case of fractions of the form $\frac{1}{1-x}$: then considering each term of his series separately, as representing a particular ordinate, he applied to it Wallis's method for curves, whose ordinates are expressed by a single term, and the sum of the partial areas so obtained gave him the value of the whole area. This was the *first* example *given to the world* of obtaining the quadrature of a curve by expanding its ordinate into an infinite series. And it was also the main secret in the general method which Newton had invented for

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* Vide Whiston's *Memoirs of himself*, page 23, *&c.*

† Born in Holstein: he passed the greater part of his life in England.

all problems of this nature. The novelty of the invention caused it to be received with general applause. Collins, a gentleman well known to science and philosophy at that time, hastened to send Mercator's book to his friend Barrow, who communicated it to Newton. The latter had no sooner glanced over it, than, recognizing his own fundamental idea, he immediately went home, to find the manuscript, in which he had explained his own method, and presented it to Barrow; this was the treatise *Analysis per æquationes numero terminorum infinitas*. Barrow was struck with astonishment at seeing so rich a collection of analytical discoveries of far greater importance than the particular one which then excited such general admiration. Perhaps, too, he must have been still more surprized at their young author having been able to keep them so profoundly secret. He immediately wrote about them to Collins, who, in return, entreated Barrow to procure for him the sight of so precious a manuscript. Collins obtained his request, and happily, before returning the work, took a copy of it, which, being found after his death among his papers, and published in 1711, has determined beyond dispute, by the date which it bore, at what period Newton made the memorable discovery of expansion by series, and of the method of fluxions. It would have been natural to suppose that an interference with his own discoveries would at last have induced Newton to publish his methods; but he preferred still to keep them secret. "I suspected,' says he, 'that Mercator must have known the extraction of roots, as well as the reduction of fractions into series by division, or at least, that others, having learnt to employ division for this purpose, would discover the rest before I myself should be old enough to appear before the public, and, therefore, I began henceforward to look upon such researches with less interest.'"

Newton was doomed to encounter difficulties as great as fall to the lot of most of us mortal beings. The following account of an incident that deprived him of the fruits of his labors of many years, must excite feelings of regret in the mind of every one:

"Newton had a favorite little dog called 'Diamond.' One winter's morning, while attending early service, he inadvertently left this dog shut up in his room; on returning from chapel, he found that the animal, by upsetting a taper on his desk, had set fire to the papers on which he had written down his experiments; and thus he saw before him the labors of so many years reduced to ashes. It is said that, on first perceiving this great loss, he contented himself by exclaiming, 'Oh, Diamond! Diamond! thou little knowest the mischief thou hast done.' But the grief caused by this circumstance—grief which reflection must have augmented, instead of alleviating—injured his health, and, if we may venture to say so, for some time impaired his understanding. This incident in Newton's life, which appears to be confirmed by many collateral circumstances, is mentioned in a manuscript note of Huygens, communicated to M. Biot, of the French Institute, by Mr. Vanswinden, in the following letter:

"'There is among the manuscripts of the celebrated Huygens, a small journal in folio, in which he used to note down different occurrences; it is side Z., No. 8, page 112, in the catalogue of the library at Leyden: the following extract is written by Huygens himself, with whose hand-writing I am well acquainted, having had occasion to peruse several of his manuscripts and autograph letters. *On the 29th May, 1694, a Scotchman of the name of Colin informed me that Isaac Newton, the celebrated mathematician, eighteen months previously, had become deranged in his mind, either from too great application to his studies, or from excessive grief at having lost, by fire, his chemical laboratory and some papers. Having made observations before the Chancellor of Cambridge, which indicated the alienation of his intellect, he was taken care of by his friends, and, being confined to his house, remedies were applied, by means of which he has lately so far recovered his health as to begin to again understand his own Principia.* Huygens mentioned this circumstance to Leibnitz, in a letter, dated the 8th of the following June, to which the latter replied on the 23d. 'I am very happy that I received information of the cure of Mr. Newton at the same time that I first heard of his illness, which, without doubt, must have been most alarming. It is to men like Newton and yourself, Sir, that I desire health and a long life.''

"This account by Huygens is corroborated by the following extract from a MS. at Cambridge, written by Mr. Abraham de le Pryne, dated February 3, 1692, in which, after mentioning the circumstance of the papers being set fire to, he says, 'But when Mr. Newton came from chapel, and had seen what was done, every one thought he would have run mad: he was so troubled thereat, that he was not himself for a month after.' From these

details, it would appear that the mind of this great man was affected, either by excess of exertion, or through grief at seeing the result of his efforts destroyed. In truth, there is nothing extraordinary in either of these suppositions; nor ought we to be astonished that the first sentiments arising from the great affliction which befell Newton were expressed without violence, for his mind was, as it were, prostrated under their weight. But the fact of a derangement in his intellect, whatever may have been the cause, will explain how, after the publication of the Principia, in 1687, Newton, though only forty-five years old, *never more* gave to the world a *new* work in any branch of science; and why he contented himself with merely publishing those that he had composed long before this epoch, confining himself to the completion of those parts that required developement."

It is evident that this great man was impressed with a true and proper sense of the omnipotence of the Almighty Creator of all things. Under the influence of such feelings he penned the following remarks, when explaining the method to be pursued in the study of Natural Philosophy:

"In his treatise on *Optics*, which he had evidently composed and inserted with intentions sincerely religious, and as genuine professions of his firm belief in a divine Providence, he says, 'the main business of this science is to argue from phenomena, without feigning hypothesis, and to deduce causes from effects, till we come to the very First Cause—which certainly is not mechanical: and not only to unfold the mechanism of the world, but chiefly to resolve these and such like questions. What is there in places almost empty of matter, and whence is it that the sun and planets gravitate towards one another, without dense matter between them? Whence is it that nature doth nothing in vain, and whence arises all that order and beauty which we see in the world? To what end are comets, and whence is it that planets move all one and the same way, in orbs concentric, while comets move all manner of ways in orbs very eccentric; and what hinders the fixed stars from falling upon one another? How came the bodies of animals to be contrived with so much art,—and for what ends were their several parts? Was the eye contrived without skill in optics, and the ear without knowledge of sounds? How do the motions of the body follow from the will, and whence is the instinct in animals? Is not the sensory of animals that place to which the sensitive substance is present; and into which the sensible species of things are carried through the nerves and brain, that there they may be perceived, by their immediate presence to that substance? And these things being rightly dispatched, does it not appear from phenomena, that there is a Being incorporeal, living, intelligent, omnipresent, who, in infinite space, as it were, in his sensory, sees the things themselves intimately, and thoroughly perceives them, and comprehends them wholly by their immediate presence to himself; and which things, the images only, carried through the organs of sense into our little sensoriums, are there seen and beheld by that which in us perceives and thinks; and though every true step made in this philosophy bring us not immediately to the knowledge of the First Cause, yet it brings us nearer to it, and on that account is to be highly valued?'

"It is thus that Newton speaks of a Supreme Being; and even those who might dispute the arguments which he gives for such an existence, must still recognize, in this passage, the sentiments of a mind deeply imbued with religious feelings, and convinced of their true foundation."

In one of the two numbers devoted to "Animal Physiology," we find the following interesting account of the wonderful preservative power of life with which some of the feathered tribe are endowed:

"If the accounts given by naturalists of the hybernating condition of certain birds be deemed worthy of credit, how much more wonderful must appear the preservative power of life, and how much more extraordinary the modifications of state in the same animal of which it will admit! That the cuckoo hybernates, and that, when accidentally found in its torpid state, it appears like a dead mass of matter—that it may be rolled about, or even struck with a considerable degree of violence, without producing the slightest sign of sensation—that its respiration and every other manifest vital action seem to be wholly suspended,—are well known facts. Equally familiar to us is the annual migration of swallows from our country, and their regular return to it in the month of April; but it is not so generally known that some of these birds, probably the young and the feeble, remain the whole year in Britain, and as the winter approaches, retiring into the hollows of trees, the clefts of rocks, and the bottom of deep caverns, fall into a torpid

state, and continue in a profound lethargy during the cold months. In the severer climates, the fact of their hybernation is still more abundantly attested; but the most extraordinary statement is that, in such countries, they precipitate themselves into the sea, and into deep lakes and rivers, at the bottom of which they remain during winter in a state of profound torpor. If such accounts may be credited, and they are attested by authorities which can scarcely be questioned, how wonderful must be the action of the vital principle in preserving the life of an animal under circumstances so extraordinary, in an element which would certainly be fatal to it in a few minutes in its ordinary state; with its respiration suspended, its circulation stopped, and its blood—in what condition must we conceive this fluid to remain? If it coagulate, which it must do in a few seconds, unless under some counteracting and controlling influence, it can no longer be a living fluid, and how then can the animal possibly revive? But if it do not coagulate, if it remain alive, and therefore fluid, though at perfect rest, and exposed to such a degree of cold for this length of time, how striking an illustration would this most singular fact afford of the uninterrupted and enduring and efficient action of the vital principle, under circumstances which would seem absolutely incompatible with its existence even for a few moments!"

The society have taken care to blend instruction with amusement in the various treatises issued under their patronage. There is much utility to be gathered from many of them; for instance, we will take the two numbers devoted to an account of the Art of Brewing, and the following circumstance so often occurs in families that we think the account of the experiment will be acceptable to many of our readers:

"An eligible mode of discovering whether beer be in a proper state to yield to finings or not is the following:

"'Draw off a little of the beer into a pint, or half-pint phial, and add to it about half a tea-spoon full of the finings. Shake it up, and then let it remain stationary. If the finings will have the desired effect, you will observe in a few minutes the isinglass collecting the feculencies of the beer into large fleecy masses, which will begin regularly to subside to the bottom. If the beer be not in a proper state, (which is ever the case as long as the fermentation continues, or an after *fret* prevails,) the bulk of the finings will soon be at the bottom, leaving the beer neither pure nor foul, except just at the top, where there will be a little transparency, perhaps a quarter of an inch deep, which will grow deeper in time, but not readily extend to the whole.'"

No drink is more wholesome and nutricious than good beer, but unfortunately it is very rarely to be found in a pure state; the brewers are obliged to sell so low to the retail venders as scarcely to leave any profit, and means are resorted to, to supply the place of malt and hops, which cannot but be injurious to the public health. For instance,

"Bruised *Green Copperas*, called also *salt of steel*, (*sulphate of iron*,) which has always been put into porter—formerly by the brewer, and now by the publican—is, ostensibly, for the purpose of giving it a *frothy top*. It is either used alone, or mixed with *alum*, and is technically called *heading*. The quantity used need not exceed as much as would lie on a half-crown piece for a barrel, and to that extent there is no danger to be feared."

Another very common practice, to which there cannot be any serious objection, is thus described:

"*Egg-shells*, and even whole eggs, are sometimes introduced into beer, in which they act the same part as the carbonates of lime. The shells are, in fact, almost wholly the same substance. The following recipe, which was first published in an early number (the 27th) of the Philosophical Transactions, shows that the use of eggs for the prevention of acidity is of no modern date. The writer (Dr. Stubbs) says that *he learned it from an ale-seller in Deal*, and that he tried it successfully in a voyage to Jamaica. 'To every runlet of five gallons, after it is placed in the ship not to be stirred any more, put in two new-laid eggs whole, and let them lie in it; in a fortnight, or little more, the whole egg-shell will be dissolved, and the eggs become like wind-eggs, inclosed only in a thin skin; after this the white is preyed on, but the yolks are not touched or corrupted, by which means the ale was so well preserved, that it was found better at Jamaica than at Deal.' It may be observed, that although this was new to Dr. Stubbs, he was not the original discoverer. It was probably known *in the trade* for centuries."

We cannot too strongly recommend this series of useful tracts to our readers; they will find much amusement blended with instruction, and the treatises will always be valuable as books of reference on almost all scientific subjects.

METEOROLOGICAL RECORD, KEPT IN THE CITY OF NEW-YORK,

From the 1st to the 30th day of June, 1833, inclusive.

Date.	Hours.	Thermometer.	Barometer.	Winds.	Strength of Wind.	Clouds from what direction.	Weather.	Remarks.
June 1	6 a. m.	62	30.10	SW	moderate	WSW	fair	
	10	68	30.13	WSW	..	..	..	
	2 p. m.	75	30.10	SSW—S	..	..	..	
	6	69	30.10	S—SSE	light	..	..	
	10	66	30.09	S	..	..	cloudy	Arithmetical mean of the thermometer for the month of June, 66.58
" 2	6 a. m.	58	30.08	SW	..	..	.. —thund'r & rain	
	10	66	30.02	SSE	moderate	WSW / SSE	.. fair, with swift scuds fr SSE	
	2 p. m.	76	29.90	..	..	WSW		
	6	70	29.80	..	..	..	.. —thund'r & rain	
	10	70	29.78	S	..	..	.. —fair	
" 3	6 a. m.	67	29.76	WSW—W	..	WSW / W	fair wind scuds fr W	
	10	72	29.79	W	fresh	.. / ..	.. .. ..	
	2 p. m.	80	29.80	NNW	..	.. / ..	.. .. ..	
	6	66	29.91	..	..	NNW	.. .. ..	
	10	53	29.08	..	moderate	..	.. .. fr NNW	Maximum eight of the barometer in June, 30.28 in.—Minimum, 29.62 in.—Range 0.66 in.
" 4	6 a. m.	50	30.15	N by W	..	W by S	..	
	10	61	30.20	NNW—NNE	..	W by S / NE	..	
	2 p. m.	66	30.20	N—NNW	light	W / N	..	
	6	66	30.20	SSW	moderate	W by N	..	
	10	60	30.22	WSW	..		..	
" 5	6 a. m.	57	30.25	..	..	WNW	..	
	10	72	30.28	SW	..	WNW / SSW	.. light scuds fr SSW	
	2 p. m.	76	30.21	S	..	.. / ..	..	
	6	68	30.15	..	..	W by N	..	
	10	65	30.16	..	..	..		The observations of surface winds for June are as follow: From the North-Eastern quarter including N. 15. From the South-Eastern, including E. 33. From the South-Western, including S. 45. And from the North-Western, including W. 47.
" 6	6 a. m.	67	30.09	SSW	light	..	cloudy — little or no rain on the Hudson above the Highlands.	
	10	65	30.06	SSE	..		rain	
	2 p. m.	67	30 01	..	..	.. / ..	..	
	6	64	29·99	S by E	..	WNW / S	cloudy	
	10	62	29.95	..	..	.. / ..	..	
" 7	6 a. m.	61	29.85	NNE	..	.. / ..	..	
	10	64	29.88	ENE—E	..		rain —fair	
	2 p. m.	66	29.81	E	..	.. / ..	cloudy	
	6	66	29.80	..	..	.. / ..	..	
	10	64	29.80	..	..	WNW	fair	
" 8	6 a. m.	64	29.81	NNE	..	..	..	
	10	66	29.85	ENE	moderate	..	hazy and foggy	
	2 p. m.	68	29.80	SSE	..	..	..	
	6	65	29.78	..	light	..	..	
	10	62	29.77	..	..	W by S	..	
" 9	6 a. m.	58	29·63	WSW-WNW	moderate	W by S / NW	fair	
	10	65	29.62	NW	fr'h-str'g		..	
	2 p. m.	66	29.65	NNW	fr'h-mod.		clear	
	6	64	29.69	..	light		..	
	10	59	29.72	..	..		..	
" 10	6 a. m.	53	29.72	W—WSW	..	NW	fair	
	10	65	29·74	SW by W	..	WNW / SW	..	
	2 p. m	72	29.63	WSW	moderate	WNW	.. —cloudy	
	6	68	29.63	WNW	..	..	cloudy	The observations of the highest current of clouds have been as follow: From the North-Eastern quarter, 0. From the South-Eastern, 1. From the South-Western, 40. From the North-Western, 68.
	10	58	29.68	NNW	..		fair	
" 11	6 a. m.	56	29.70	NW—NNW	..	NW	..	
	10	65	29.74	NW—W	fresh	..	..	
	2 p. m.	72	29.75	..	..	..	..	
	6	64	29.80	..	moderate		clear	
	10	60	29.84	..	light		..	
" 12	6 a. m.	55	29.95	WNW	..		fair	
	10	66	29.98	..	moderate	WNW	..	
	2 p. m.	74	29.97	W—WSW	..	..	..	
	6	72	29.95	W	light	..	..	
	10	68	30.00	..	..	W by N	.. cloudy at west	
" 13	6 a. m.	61	30·03	ENE	..	W by N / WSW	..	
	10	70	30.05	S—ENE	moderate	.. / ..	..	
	2 p. m.	79	29.95	SSE	fresh	.. / ..	.. —cloudy	

*CITY OF NEW-YORK—CONTINUED.

Date.	Hours.	Thermometer.	Barometer.	Winds.	Strength of Wind.	Clouds from what direction.	Weather
June 13	6 p. m.	71	29·87	SSE	moderate	W by N / WSW / S	cloudy
	10	69	29.80		..		.. -lightn'g-thun. st.
" 14	6 a. m.	68	29.80	WSW	..	WSW	fair
	10	74	29.80	..	..	W	..
	2 p. m.	80	29.77	..	light	..	cloudy—fair
	6	74	29.78	..	..	..	fair
	10	69	29.84	..	..		..
" 15	6 a. m.	65	29.84	..	faint	WSW	..
	10	72	29.84	SSW	light	WSW—W	..
	2 p. m.	79	29.78	..	..	WSW	..
	6	76	29.74	SSW—WSW	..	..	.. haze at NW
	10	72	29.74	WSW	..	..	hazy
" 16	6 a. m.	63	29.75	NW	moderate	NW	fair scuds fr NW
	10	75	29.77	WNW	..	WNW	..
	2 p. m.	79	29.73	WSW	fresh	..	..
	6	75	29.71	SW	moderate	..	..
	10	70	29.75	..	..	..	..
" 17	6 a. m.	63	29.80	W—WNW	..	W	..
	10	70	29.85	NW	fresh	WNW	..
	2 p. m.	75	29.89	NNW	moderate	NW	..
	6	68	29.91	..	..		
	10	65	29.99				
" 18	6 a. m.	61	30·07	NNE—NE	..	NW / NE	..
	10	66	30·15	ENE	..	NW / ENE / SW	..
	2 p. m.	72	30·18	S—SSE	..	WNW / NE	..
	6	67	30.15	SSE	.	NNW	..
	10	62	30.20	WSW	light		..
" 19	6 a. m.	60	30·20	..	..	NW / SW	..
	10	66	30.21	S—SSE	moderate	..	..
	2 p. m.	72	30.18	SSE	..	..	.. —cloudy
	6	67	30.12	ESE	fresh		cloudy —rainy
	10	66	30.15	..	..		rain
" 20	6 a. m.	65	30.09	SSE	moderate		rainy
	10	68	30.09	..	..		cloudy
	2 p. m.	71	30.10	..	..		..
	6	68	30.09	..	..		..
	10	67	30.09	..	..		..
" 21	6 a. m.	65	30.07	..	..		.. —rainy
	10	67	30.07	S by E	..		rain
	2 p. m.	68	30.07	..	..		..
	6	68	30·01	N	..	S / ENE	.. swift scuds fr NE
	10	65	29.98	..	..		cloudy
" 22	6 a. m.	65	29.99	NNW	..	NW	fair —cloudy
	10	70	29.98	..	..	..	..
	2 p. m.	78	29.97	..	..	..	.. shower at 3½ o'c.
	6	74	29.95	..	..	..	..
	10	70	29.97	..	light	..	..
" 23	6 a. m.	68	29.98	NW	..	WNW	..
	10	76	29.97	..	..	..	..
	2 p. m.	81	29.96	W	..	..	..
	6	76	29.94	..	..	..	..
	10	70	29.93	..	..	..	cloudy
" 24	6 a. m.	66	29.88	E	..	SE	.
	10	65	29.90	ESE	moderate	..	..
	2 p. m.	68	29.80	..	..	..	rainy
	6	67	29.72	..	fresh	..	rain —heavy rain
	10	64	29.70	..	..	..	..
" 25	6 a. m	63	29·60	NW	moderate	SW / NW	cloudy —fair
	10	66	29.62	WNW—W	fresh	W by S	fair
	2 p. m.	70	29.62	WNW	..	..	..
	6	64	29.71	..	..	..	..
	10	60	29.75	..			cloudy
" 26	6 a. m.	59	29.80	NW—E	light	SW by N	rainy —rain
	10	62	29.82	E—WNW	faint	SW by W / WNW	fair —cloudy
	2 p. m.	62	29.80	N	..	..	cloudy —fair
	6	61	29.82	..	.	..	fair

Remarks.

The prevalence of North-Westerly winds, both at the surface and in the upper current, have been greater than has been observed in any month during the present year. An unusual quantity of rain for the month of June has also fallen.

On the 2d day of June, tornadoes, hail-storms, and thunder-storms, appeared at various places in different parts of the United States. In the states of Maryland and Pennsylvania the most violent of these appeared in the afternoon; in the state of New-York and in New-England, in the evening. On the night previous a heavy tornado occurred in Illinois. Since that period, storms of this character have occurred in a few instances, particularly on the 17th, when a most severe tornado passed over Delaware county.

The heavy rain which fell in this city on the evening of the 24th June was some hours later in its occurrence in the eastern parts of Long Island Sound, as appears by the reports of the Providence steamboats. During this rain the wind was from ESE, being a di-

CITY OF NEW YORK—CONTINUED.

Date.	*Hours.*	*Thermometer.*	*Barometer*	*Winds.*	*Strength of Wind.*	*Clouds from what direction.*	*Weather.*	*Remarks*
June 26	10 p.m.	60	30·03		faint		cloudy —fair	
" 27	6 a. m.	61	30·05	w by s	moderate	wsw	fair	
	10	66	30·09	wnw	..	..	..	rection nearly opposite to the pro-
	2 p. m	70	30·11	..	..	..	..	gress of the rain. Heavy rain al-
	6	66	30·15	nw	..	..	..	so fell at Cincinnati on the 23d
	10	63	30·10				..	and on the morning of the 24th,
" 28	6 a. m.	58	30·09	ne	faint	..	..	which may have been connected
	10	66	30·09	wsw	..	..	..	with that which fell here on the
	2 p. m.	75	30·14	ssw	light	..	cloudy	night of the 24th.
	6	70	30·15	s	faint	..	.. —fair	
	10	66	30·14				fair	
" 29	6 a. m.	61	30·11	n	light	wnw	..	
	10	68	30·13	ne	..	..	..	
	2 p. m.	73	30·14	wsw	..	..	..	
	6	72	30·19	sw	..	..	..	
	10	68	30·12	..	..	..	..	
" 30	6 a. m.	67	30·09	..	..	..	..	
	10	72	30·08	..	..	..	..	
	2 p. m.	80	30·07	s	moderate	..	.	
	6	75	30·05	..	..		clear	
	10	70	30·01	sw	..		..	

METEOROLOGICAL RECORD, KEPT AT AVOYLLE FERRY, RED RIVER, LOU.

For the months of February, March, April, and May, 1833—(*Latitude* 31.10 *N.*, *Longitude* 91.59 *W. nearly.*)

Date. 1833.	*Thermometer.* Morn'g.	Noon.	Night.	*Wind.*	*Weather, Remarks, &c.*
Feb'y 1	41	60	56	calm	clear—river rising half an inch a day
" 2	52	56	54	..	.. —cloudy evening
" 3	46	58	59	ne	.. —calm evening
" 4	42	64	62	calm	.. —peas up
" 5	43	58	61	..	..
" 6	52	61	56	..	cloudy all day
" 7	41	60	60	..	.. morning—clear day
" 8	37	66	64	..	clear—white frost
" 9	41	67	66	..	.. —lettuce, full large heads
" 10	47	68	66	..	.. morning—cloudy evening
" 11	57	73	71	..	cloudy morning—clear evening
" 12	62	70	70	s—high	.. —at night heavy rain
" 13	50	60	60	nw	clear
" 14	45	43	42	ne, morn'g	cloudy—rain all day—calm evening
" 15	40	43	45	calm	.. — .. .. —heavy showers
" 16	52	60	61	..	.. —river rising one inch a day
" 17	48	58	60	..	.. —showers
" 18		56		..	..
" 19		64		..	clear
" 20	50	58	56	nw—high	..
" 21	48	59	61	calm	..
" 22	52	60	59	..	cloudy
" 23	56	62	61	..	.. —rain and thunder
" 24	51	58	48	nw—high	clear—cloudy evening
25	38	52	52	calm	cloudy
" 26	47	60	56	e—light	.. —evening calm and rain
" 27	56	63	62	calm	.. —light showers all day [river risen this month 2 ft. 8 in.
" 28	66	75	70	s—high	.. —gale in the evening and night—at midnight wind n—a severe gale—
March 1	39	36	32	n—severe	.. —rain and spits of snow (the first this winter
" 2	28	42	38	..	clear—calm evening—ice—martin birds appeared
" 3	30	50	49	calm	.. all day
" 4	39	62	60	se—light	cloudy—calm evening
" 5	52	60	62	calm	.. —rain all day
" 6	58	59	56	n	.. —rain in the morning—evening clear and calm
" 7	46	58	52	calm	.. —rain all day
" 8	48	59	58	n—severe	clear all day
" 9	40	66	63	calm	.. ..
" 10	47	70	66	s—light	.. ..
" 11	56	70	67	s—severe	cloudy all day
" 12	62	71	64	s	.. .. —calm and rain all night
" 13	60	58	56	calm	.. —rain in the morning
" 14	56	62	61	..	.. —rain all day
" 15	59	58	53	..	.. — .. .. and night remarkably heavy
" 16	58	62	62	..	foggy morning—rain and thunder severe all day and night
" 17	63	64	64	..	cloudy—rain and thunder all day and night, severe and heavy
" 18	65	66	64	s—severe	gales — .. .. ..
" 19	68	73	72	calm	.. —rain—light showers in the evening—wind s and light

AVOYLLE FERRY, RED RIVER, LOU.—CONTINUED.

Date. 1833.	*Thermometer.* Morn'g.	Noon.	Night.	*Wind.*	*Weather, Remarks, &c.*
Mar. 20	60	70	74	W	cloudy—evening clear and calm
" 21	51	68	59	calm	clear all day and night—planted corn, beans, &c.
" 22	47	73	64	..	.. .. ..
" 23	56	68	62	..	.. — rain in the evening—wind NW and high all night
" 24	54	72	66	NW	.. — calm evening
" 25	54	71	65	calm	cloudy morning—clear day
" 26	54	74	64	..	clear—rain at night
" 27	60	71	65	..	cloudy—rain and thunder at night from NW, high
" 28	56	52	49	NW	.. —wind high all day and night
" 29	41	59	56	N—light	clear — .. .. .. —gathered turnip and mustard seed
" 30	40	61	58	E—light	.. —light white frost
" 31	42	66	67	NE—light	.. all day and night—Red River at a stand
April 1	58	63	64	SE—strong	cloudy—rain & thunder afternoon & night—gathered mustard & turnip seed
" 2	62	76	70	calm	foggy morning—clear day
" 3	55	80	71	..	clear—planted sweet potatoes, two acres
" 4	60	72	64	NE—light	.. all day—Red River rising
5	58	74	62	..	.. .. [severe till 12, midnight
" 6	60	66	62	SE—light	cloudy—li ht thunder showers all day—calm at night—rain and thunder
" 7	60	73	66	W	clear
" 8	54	76	63	calm	..
" 9	56	78	67	..	..
" 10	60	74	70	..	cloudy evening—wind S
" 11	68	75	69	S	.. all day
" 12	61	80	66	..	clear—cloudy night
" 13	58	72	62	NE	.. —evening, wind N, and heavy thunder and rain, and at night
" 14	56	58	60	NE—strong	cloudy—calm late in evening and night
" 15	57	66	61	NE—light	.. morning—evening light showers and calm
" 16	58	70	64	W—light	cloudy—evening light showers and calm—peas ripe
" 17	57	72	61	NW—light	clear
" 18	52	76	67	N—light	.. —calm and cloudy night
" 19	58	74	68	E—light	cloudy—calm—clear evening and night
" 20	66	78	71	calm	.. morning— .. .. ..
" 21	65	82	77	..	clear
" 22	70	81	74	..	..
" 23	64	85	72	..	.. —at 5 p. m. shower and very heavy thunder
" 24	64	82	78	..	..
" 25	65	82	74	..	..
" 26	65	83	76	SE—light	cloudy morning—clear—calm day
" 27	66	81	73	SE—high	clear [then calm and cloudy
" 28	72	65	63	SE—severe	cloudy—at 12, noon, a severe gale and rain from W, continued until 4 p. m.—
" 29	65	80	74	calm	.. —even'g & night, heavy thunder showers—new potatoes fit for use
" 30	70	80	76	SE—light	clear—evening, wind high—sweet potatoes come up
May 1	66	79	70	SE—strong	cloudy—light showers
" 2	68	74	73	calm	.. —heavy showers—night calm and clear
" 3	66	72	66	..	.. —light thunder showers—evening wind N and light
" 4	65	80	72	..	clear morning—evening heavy thunder showers—wind S and strong
" 5	63	80	71	..	.. .. SE, light
" 6	66	82	72	..	.. .. —night thunder and light showers
" 7	68	77	71	..	cloudy—evening light showers—wind SE
" 8	69	79	70	NE—light	.. —heavy rain at night and calm
" 9	66	78	70	..	.. —rain, and in evening light showers
" 10	68	82	72	calm	.. morning—evening heavy thunder showers
" 11	66	84	71	..	clear—evening light showers and heavy thunder
" 12	67	78	72	..	.. — .. heavy showers from N—thunder severe and at night
" 13	68	73	73	..	cloudy— .. . . —rain severe—Red River falling
" 14	67	80	77	..	clear all day
" 15	66	85	78	..	.. ..
" 16	71	81	76	..	.. ..
" 17	69	83	78	..	.. —evening wind S
" 18	72	82	72	S—light	cloudy evening—thunder shower from NW, severe
" 19	70	84	80	calm	clear
" 20	70	83	79	SW	.. —at night a gale from W—thunder and rain severe
" 21	68	82	72	W, morning	cloudy—calm evening
" 22	71	75	70	SE	.. —rain and thunder heavy all day and night
" 23	68	80	73	W, morning	clear—calm evening
" 24	69	81	73	calm	.. —light flying clouds all day
" 25	68	76	80	..	..
" 26	70	77	80	..	..
" 27	72	87	80	..	..
" 28	75	86	80	SW—light	..
" 29	72	79	73	N, morning	cloudy—rain and thunder severe in evening
" 30	72	84	79	calm	.. morning—clear day
" 31	72	82	80	S	. .. —evening clear

Note.—Red River rose in February 2 feet 8 inches—in March 2 ft. 10 in.—and in April 4 inches, which was within 3½ inches of extreme high water of 1828; in May, it had fallen 4½ inches, being 8 inches below high water mark.

Babbage, Charles.

APPENDIX.

[In accordance with our notice on the second page of the wrapper, we now commence the re-print of Mr. Babbage's book. Again we beg to remind our readers, that the pages and sheets are so arranged that the book can be bound either as part of the volume of the Magazine, or without it: to bind it with the Magazine we should consider the most judicious, as the index to each volume will be copious, and refer generally to Mr. Babbage's book.]

ON THE ECONOMY OF MANUFACTURES.

INTRODUCTION.

The object of the present volume is to point out the effects and the advantages which arise from the use of tools and machines; to endeavor to classify their modes of action; and to trace both the causes and the consequences of applying machinery to supersede the skill and power of the human arm.

A view of the mechanical part of the subject will, in the first instance, occupy our attention, and to this the first section of the work will be devoted. The first chapter of the section will contain some remarks on the general sources from whence the advantages of machinery are derived, and the succeeding nine chapters will contain a detailed examination of principles of a less general character. The eleventh chapter contains numerous subdivisions, and is important from the extensive classification it affords of the arts in which copying is so largely employed. The twelfth chapter, which completes the first section, contains a few suggestions for the assistance of those who propose visiting manufactories.

The second section, after an introductory chapter on the difference between *making* and *manufacturing*, will contain, in the succeeding chapters, a discussion of many of the questions which relate to the political economy of the subject. It was found that the domestic arrangement, or interior economy of factories, was so interwoven with the more general questions, that it was deemed unadvisable to separate the two subjects. The concluding chapter of this section, and of the work itself, relates to the future prospects of manufactures, as arising from the application of science.

SOURCES OF THE ADVANTAGES ARISING FROM MACHINERY AND MANUFACTURES.

1. There exists, perhaps, no single circumstance which distinguishes our country (England) more remarkably from all others, than the vast extent and perfection to which we have carried the contrivance of tools and machines for forming those conveniences, of which so large a quantity is consumed by almost every class of the community. The amount of patient thought, of repeated experiment, of happy exertion of genius, by which our manufactures have been created and carried to their present excellence, is scarcely to be imagined. If we look around the rooms we inhabit, or through those storehouses of every convenience, of every luxury that man can desire, which deck the crowded streets of our larger cities, we shall find in the history of each article, of every fabric, a series of failures which have gradually led the way to excellence; and we shall notice, in the art of making even the most insignificant of them, processes calculated to excite our admiration by their simplicity, or to rivet our attention by their unlooked-for results.

2. The accumulation of skill and science which has been directed to diminish the difficulty of producing manufactured goods, has not been beneficial to that country alone in which it is concentrated; distant kingdoms have participated in its advantages. The luxurious natives of the East,* and the ruder inhabitants of the African desert, are alike indebted to our looms. The produce of our factories has preceded even our most enterprising travellers.† The cotton of India is conveyed by British ships round half our planet, to be woven by British skill in the factories of Lancashire: it is again set in motion by British capital; and, transported to the very plains whereon it grew, is re-purchased by the lords of the soil which gave it birth, at a cheaper price than that at which their coarser machinery enables them to manufacture it themselves.‡

3. The large proportion of the population of this country, who are engaged in manufactures, appears from the following table, deduced from a statement in an Essay on the Distribution of Wealth, by the Rev. R. Jones:

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* The Bandana handkerchiefs manufactured at Glasgow have long superseded the genuine ones, and are now consumed in large quantities both by the natives and Chinese.—[Crawfurd's Indian Archipelago, vol. iii. p. 505.]

† Captain Clapperton, when on a visit at the court of the Sultan Bello, states that "provisions were regularly sent me from the Sultan's table on pewter dishes with the London stamp; and I even had a piece of meat served up on a white wash-hand basin of English manufacture."—[Clapperton's Journey, p. 88.]

‡ At Calicut, in the East Indies, (whence the cotton cloth called calico derives its name,) the price of labor is one seventh of that in England, yet the market is supplied from British looms.

For every hundred persons employed in Agriculture, there are,

	Agriculturists.	Non-Agriculturists.
In Italy	100	31
In France	100	50
In England	100	200

The fact that the proportion of non-agricultural to agricultural persons is continually increasing, appears both from the Report of the Committee of the House of Commons upon Manufacturers' Employment, July, 1830, and also from the still later evidence of the last census, from which document the annexed table of the increase of population in our great manufacturing towns has been deduced.

Increase of population per cent.:

Names of Places.	1801 to 1811.	1811 to 1821.	1821 to 1831.	Total. 1801 to 1831.
Manchester,	22	40	47	151
Glasgow,	30	46	38	161
Liverpool,*	26	31	44	138
Nottingham,	19	18	25	75
Birmingham,	16	24	33	90

Thus, in three periods of ten years each, during each of which the general population of the country has increased about 15 per cent., or nearly 51 per cent. upon the whole period of thirty years, the population of these towns has, on the average, increased 123 per cent. After this statement, the vast importance to the well-being of this country, of making the interests of its manufactures well understood and attended to, needs no farther argument.

4. The advantages which are derived from machinery and manufactures seem to arise principally from three sources, viz.: The addition which they make to human power; The economy they produce of human time; The conversion of substances apparently common and worthless into valuable products.

5. *Of additions to human power.* With respect to the first of these causes, the forces derived from wind, from water, and from steam, present themselves to the mind of every one; these are, in fact, additions to human power, and will be considered in a future page: there are, however, other sources of its increase, by which the animal force of the individual is itself made to act with far greater than its unassisted power; and to these we shall at present confine our observations. The construction of palaces, of temples, and of tombs, seems to have occupied the earliest attention of nations just entering on the career of civilization; and the enormous blocks of stone moved from their native repositories to minister to the grandeur or piety of the builders, have remained to excite the astonishment of their posterity long after the purposes of many of these records, as well as the names of their founders, have been forgotten. The different degrees of force necessary to move these ponderous masses will have varied according to the mechanical knowledge of the people employed in their transport; and that the extent of power required for this purpose is widely different under different circumstances will appear from the following experiment, which is related by M. Redelet, *Sur l'Art de Batir.*

A block of squared stone was taken for the subject of experiment:

1.	Weight of stone	1080 lbs.
2.	In order to drag this stone along the floor of the quarry, roughly chiselled, it required a force equal to	758
3.	The same stone dragged over a floor of planks, required	652
4.	The same stone placed on a platform of wood, and dragged over a floor of planks, required	606
5.	After soaping the two surfaces of wood which slid over each other, it required	182
6.	The same stone was now placed upon rollers of three inches diameter, when it required to put it in motion along the floor of the quarry	34
7.	To drag it by these rollers over a wooden floor	28
8.	When the stone was mounted on a wooden platform, and the same rollers placed between that and a plank floor, it required	22

From this experiment, it results that the force necessary to move a stone along the roughly chiselled floor of its quarry is nearly two-thirds of its weight; to move it along a wooden floor, three-fifths: by wood upon wood, five-ninths; if the wooden surfaces are soaped, one-sixth; if rollers are used on the floor of the quarry, it requires one-thirty-second part of the weight; if they roll over wood, one-fortieth; and if they roll between wood, one-fiftieth of its weight. At each increase of knowledge, as well as on the contrivance of every new tool, human labor becomes abridged. The man who contrived rollers invented a tool by which his power was quintupled. The workman who first suggested the employment of soap, or grease, was immediately enabled to move, without exerting a greater effort, more than three times the weight he could before.*

6. *The economy of human time* is the next advantage of machinery in manufactures. So extensive and important is this effect, that we might, if we were inclined to generalize, embrace almost all the advantages under this single head; but the elucidation of principles of less extent will contribute more readily to a knowledge of the subject; and, as numerous

* Liverpool, though not itself a manufacturing town, has been placed in this list, from its great connection with Manchester, of which it is the port.

* So sensible are the effects of grease in diminishing friction, that the drivers of sledges in Amsterdam, on which heavy goods are transported, carry in their hand a rope soaked in tallow, which they throw down from time to time before the sledge, in order that it may, by passing over the rope, become greased.

examples will be presented to the reader in the ensuing pages, we shall restrict our illustrations upon this point.

As an example of the economy of time, the use of gunpowder in blasting rocks may be noticed. Several pounds of that substance may be purchased for a sum acquired by a few days' labor; yet when this is employed for the purpose alluded to, effects are frequently produced which could not, even with the best tools, be accomplished by other means in less than many months.

7. The art of using the diamond for cutting glass has undergone, within a few years, a very important improvement. A glazier's apprentice, when using a diamond set in a conical ferrule, as was always the practice about twenty years since, found great difficulty in acquiring the art of using it with certainty, and at the end of a seven years' apprenticeship many were found but indifferently skilled in its employment. This arose from the difficulty of finding the precise angle at which the diamond cuts, and of guiding it along the glass at the proper inclination when that angle is found. Almost the whole of the time consumed, and of the glass destroyed, in acquiring the art of cutting glass, may now be saved by the use of an improved tool. The gem is set in a small piece of squared brass, with its edge nearly parallel to one side of the square. A person skilled in its use now files away one side of the brass, until, by trial, he finds that the diamond will make a clean cut, when guided by keeping this edge pressed against a ruler. The diamond and its mounting are now attached to a stick similar to a pencil, by means of a swivel allowing a small angular motion. Thus the merest tyro at once applies the cutting edge at the proper angle, by pressing the side of the brass against a ruler; and even though the part he holds in his hand should deviate a little from the required angle, it communicates no irregularity to the position of the diamond, which rarely fails to do its office when thus employed.

The relative hardness of the diamond, in different directions, is a singular fact. An experienced workman, on whose judgment I can rely, informed me that he had seen a diamond ground with diamond powder on a cast iron mill for three hours without its being at all worn, but that, changing its direction with reference to the grinding surface, the same edge was ground down.

8. *Employment of materials of little value.* The skins used by the goldbeater are produced from the offal of animals. The hoofs of horses and cattle and other horny refuse, are employed in the production of the prussiate of potash, that beautiful yellow crystalized salt which is exhibited in the shops of some of our chemists. The worn out saucepans and tin ware of our kitchens, when beyond the reach of the tinker's art, are not utterly worthless. We sometimes meet carts loaded with old tin kettles and worn out iron coal-scuttles, traversing our streets. These have not yet completed their useful course; the less corroded parts are cut into strips, punched with small holes, and varnished with a coarse black varnish for the use of the trunk-maker, who protects the edges and angles of his boxes with them; the remainder are conveyed to the manufacturing chemists in the outskirts of the town, who employ them, in conjunction with pyroligneous acid, in making a black die for the use of calico printers.

9. *Of tools.* The difference between a *tool* and a *machine* is not capable of very precise distinction; nor is it necessary, in a popular explanation of those terms, to limit very strictly their acceptation. A *tool* is usually more *simple* than a machine; it is generally used with the hand, whilst a machine is frequently moved by animal or steam power. The simpler *machines* are often merely one or more *tools* placed in a frame, and acted on by any moving power. In pointing out the advantages of *tools,* we shall commence with some of the simplest.

10. To arrange twenty thousand needles thrown promiscuously into a box, mixed and entangled with each other in every possible direction, in such a form that they shall be all parallel to each other, would, at first sight, appear a most tedious occupation; in fact, if each needle were to be separated individually, many hours must be consumed in the process. Yet this is an operation which must be performed many times in the manufacture of needles; and it is accomplished in a few minutes by a very simple *tool;* nothing more being requisite than a small flat tray of sheet iron, slightly concave at the bottom. The needles are placed in it and shaken in a peculiar manner, by throwing them up a very little, and giving at the same time a slight longitudinal motion to the tray. The shape of the needles assists their arrangement; for if two needles cross each other, (unless, which is exceedingly improbable, they happen to be precisely balanced,) they will, when they fall on the bottom of the tray, tend to place themselves side by side, and the hollow form of the tray assists this disposition. As they have no projection in any part to impede this tendency, or to entangle each other, they are, by continually shaking, arranged lengthwise, in three or four minutes. The direction of the shake is now changed, the needles are but little thrown up, but the tray is shaken endways; the result of which is, that in a minute or two the needles which were previously arranged endways become heaped up in a wall, with their ends against the extremity of the tray. They are now removed by hundreds at a time, by raising them with a broad iron spatula, on which they are retained by the forefinger of the left hand. During the progress of the needles towards their finished state, this parallel arrangement must be repeated many times; and unless a cheap and expeditious method had been devised, the expense of manufac-

turing needles would have been considerably enhanced.

11. Another process in the art of making needles furnishes an example of one of the simplest contrivances which can come under the denomination of a *tool*. After the needles have been arranged in the manner just described, it is necessary to separate them into two parcels, in order that their points may be all in one direction. This is usually done by women and children. The needles are placed sideways in a heap, on a table, in front of each operator, just as they are arranged by the process above described. From five to ten are rolled towards this person by the fore-finger of the left hand; this separates them a very small space from each other, and each in its turn is pushed lengthwise to the right or to the left, according as its eye is on the right or the left hand. This is the usual process, and in it every needle passes individually under the finger of the operator. A small alteration expedites the process considerably: the child puts on the fore-finger of its right hand a small cloth cap or finger-stall, and rolling out of the heap from six to twelve needles, he keeps them down by the fore-finger of the left hand, whilst he presses the fore-finger of the right hand gently against their ends; those which have the points towards the right hand stick into the finger-stall; and the child, removing the finger of the left hand, slightly raises the needles sticking into the cloth, and then pushes them towards the left side. Those needles which had their eyes on the right hand do not stick into the finger cover, and are pushed to the heap on the right side previously to the repetition of this process. By means of this simple contrivance each movement of the finger, from one side to the other, carries five or six needles to their proper heap; whereas, in the former method, frequently only one was moved, and rarely more than two or three were transported at one movement to their place.

12. Various operations occur in the arts in which the assistance of an additional hand would be a great convenience to the workman, and in these cases tools or machines of the simplest structure come to our aid; vices of different forms in which the material to be wrought is firmly grasped by screws, are of this kind, and are used in almost every workshop; but a more striking example may be found in the trade of the nail-maker.

Some kinds of n ails, such as those used for defending the soles of coarse shoes, called hob-nails, require a particular form of the head, which is made by the stroke of a die. The workman holds the red-hot rod of iron out of which he forms them in his left hand; with his right hand he hammers the end of it into a point, and cutting the proper length almost off, bends it nearly at right angles. He puts this into a hole in a small stake-iron, immediately under a hammer connected with a treadle, which has a die sunk in its surface corresponding to the intended form of the head; and having given one part of the form to the head by the small hammer in his hand, he moves the treadle with his foot, which disengages the other hammer, and completes the figure of the head; the returning stroke produced by the movement of the treadle striking the finished nail out of the hole in which it was retained. Without this substitution of his foot for another hand, the workman would, probably, be obliged to heat the nails twice over.

13. Another, although fortunately a less general substitution of tools for human hands, is used to assist the labor of those who are deprived by nature, or by accident, of some of their limbs. Those who have had an opportunity of examining the beautiful contrivances for the manufacture of shoes by machinery, which we owe to the fertile invention of Mr. Brunel, must have noticed many instances in which the workmen were enabled to execute their task with precision, although laboring under the disadvantages of the loss of an arm or a leg. A similar instance occurs at Liverpool, in the Institution for the Blind, where a machine is used by those afflicted with blindness, for weaving sash-lines; it is said to have been the invention of a person suffering under that calamity. Other instances might be mentioned of contrivances for the use, the amusement, or the instruction of the wealthier classes, who labor under the same natural disadvantages. These triumphs of skill and ingenuity deserve a double portion of our admiration when applied to mitigate the severity of natural or accidental misfortune—when they supply the rich with occupation and knowledge—when they relieve the poor from the additional evils of poverty and want.

15. *Division of the objects of machinery.* There exists a natural, although, in point of number, a very unequal division amongst machines: they may be classed as, 1st, Those which are employed to produce power; and as, 2dly, Those which are intended merely to transmit force and execute work. The first of these divisions is of great importance, and is very limited in the variety of its species, although some of those species consist of numerous individuals.

Of that class of mechanical agents by which motion is transmitted—the lever, the pulley, the wedge, and many others—it has been demonstrated that no power is gained by their use, however combined. Whatever force is applied at one point can only be exerted at some other, diminished by friction and other incidental causes; and it has been farther proved, that whatever is gained in the rapidity of execution is compensated by the necessity of exerting additional force. These two principles, long since placed beyond the reach of doubt, cannot be too constantly borne in mind. But in limiting our attempts to things which are possible, we are still, as we hope to show, possessed of a field of inexhaustible research, and of advantages derived from mechanical skill, which have but

just begun their influence on our arts, and may be pursued without limit—contributing to the improvement, the wealth, and the happiness of our race.

15. Of those machines by which we produce power, it may be observed, that although they are to us immense acquisitions, yet in regard to two of the sources of this power—the force of wind and of water—we merely make use of bodies in a state of motion by nature; we change the directions of their movement, in order to render them subservient to our purposes, but we neither add to nor diminish the quantity of motion in existence. When we expose the sails of a wind-mill obliquely to the gale, we check the velocity of a small portion of the atmosphere, and convert its own rectilinear motion into one of rotation in the sails; we thus change the direction of force, but we create no power. The same may be observed with regard to the sails of a vessel: the quantity of motion given by them is precisely the same as that which is destroyed in the atmosphere. If we avail ourselves of a descending stream to turn a water-wheel, we are appropriating a power which nature may appear, at first sight, to be uselessly and irrecoverably wasting, but which, upon due examination, we shall find she is ever repairing by other processes. The fluid which is falling from a higher to a lower level, carries with it the velocity due to its revolution with the earth at a greater distance from its centre. It will, therefore, accelerate, although to an almost infinitesimal extent, the earth's daily rotation. The sum of all these increments of velocity, arising from the descent of all the falling waters on the earth's surface, would in time become perceptible, did not nature, by the process of evaporation, convey the waters back to their sources; and thus, again, by removing matter to a greater distance from the centre, destroy the velocity generated by its previous approach.

16. The force of vapor is another fertile source of moving power; but even in this case it cannot be maintained that power is created. Water is converted into elastic vapor by the combustion of fuel. The chemical changes which thus take place are constantly increasing the atmosphere by large quantities of carbonic acid and other gasses noxious to animal life. The means by which nature decomposes or reconverts these elements into a solid form, are not sufficiently known: but if the end could be accomplished by mechanical force, it is almost certain that the power necessary to produce it would at least equal that which was generated by the original combustion. Man, therefore, does not create power; but availing himself of his knowledge of nature's mysteries, he applies his talents to diverting a small and limited portion of her energies to his own wants: and, whether he employs the regulated action of steam, or the more rapid and tremendous effects of gunpowder, he is only producing on a small scale compositions and decompositions which nature is incessantly at work in reversing, for the restoration of that equilibrium which we cannot doubt is constantly maintained throughout even the remotest limits of our system. The operations of man participate in the character of their Author; they are diminutive, but energetic during the short period of their existence: whilst those of nature, acting over vast spaces, and unlimited by time, are ever pursuing their silent and resistless career.

17. In stating the broad principle, that all combinations of mechanical art can only augment the force communicated to the machine at the expense of the time employed in producing the effect, it might perhaps be imagined that the assistance derived from such contrivances is small. This is, however, by no means the case; since the almost unlimited variety they afford enables us to exert to the greatest advantage whatever force we employ. There is, it is true, a limit beyond which it is impossible to reduce the power necessary to produce any given effect, but it very seldom happens that the methods first employed at all approach that limit. In dividing the knotted root of a tree for the purposes of fuel, how very different will be the time consumed, according to the nature of the tool made use of! The hatchet, or the adze, will divide it into small parts, but will consume a large portion of the workman's time. The saw will answer the same purpose more effectually and more quickly. This, in its turn, is superseded by the wedge, which rends it in a still shorter time. If the circumstances are favorable, and the workman skilful, the time and expense may be still farther reduced by the use of a small quantity of gunpowder exploded in holes judiciously placed in the block.

18. When a mass of matter is to be removed, a certain force must be expended; and upon the proper economy of this force the price of transport will depend. A country must, however, have reached a high degree of civilization before it will have approached the limit of this economy. The cotton of Java is conveyed in junks to the coast of China; but from the seed not being previously separated, three-quarters of the weight thus carried is not cotton. This might, perhaps, be justified in Java by the want of machinery to separate the seed, or by the relative cost of the operation in the two countries. But the cotton itself, as packed by the Chinese, occupies three times the bulk of an equal quantity shipped by Europeans for their own markets. Thus the freight of a given quantity of cotton costs the Chinese nearly twelve times the price to which, by a proper attention to mechanical methods, it might be reduced.*

ACCUMULATING POWER.

19. Whenever the work to be done requires more force for its execution than can be gene-

* Crawfurd's Indian Archipelago.

rated in the time necessary for its completion, recourse must be had to some mechanical method of preserving and condensing a part of the power exerted previously to the commencement of the process. This is most frequently accomplished by a fly-wheel, which is in fact nothing more than a wheel having a very heavy rim, so that the greater part of its weight is near the circumference. It requires great power applied for some time to put this into rapid motion; but when moving with considerable velocity, the effects are exceedingly powerful, if its force be concentrated upon a small object. In some of the iron works where the power of the steam-engine is a little too small for the rollers which it drives, it is usual to set the engine at work a short time before the red-hot iron is ready to be removed from the furnace to the rollers, and to allow it to work with great rapidity until the fly has acquired a velocity rather alarming to those unused to such establishments. On passing the softened mass of iron through the first groove, the engine receives a great and very perceptible check; and its speed is diminished at the next and at each succeeding passage, until the iron bar is reduced to such a size that the ordinary power of the engine is sufficient to roll it.

20. The powerful effect of a large fly-wheel, when its force can be concentrated in a point, was curiously illustrated at one of the largest of our manufactories. The proprietor was showing to a friend the method of punching holes in iron plates for the boilers of steam-engines. He held in his hand a piece of sheet-iron, three-eighths of an inch thick, which he placed under the punch. Observing, after several holes had been made, that the punch made its perforations more and more slowly, he called to the engine-man to know what made the engine work so sluggishly, when it was found that the fly-wheel and punching apparatus had been detached from the steam-engine just at the commencement of his experiment.

21. Another mode of accumulating power arises from lifting a weight and then allowing it to fall. A man, even with a heavy hammer, might strike repeated blows upon the head of a pile without producing any effect. But if he raises a much heavier hammer to a much greater height, its fall, though far less frequently repeated, will produce the desired effect.

REGULATING POWER.

22. Uniformity and steadiness in the rate in which machinery works are essential both for its effect and its duration. That beautiful contrivance, the governor of the steam-engine, must immediately occur to all who are familiar with that admirable machine. Wherever the increased speed of an engine would lead to injurious or dangerous consequences, it is applied; and is equally the regulator of the water-wheel which drives a spinning-jenny, or of the windmills which drain our fens. In the dock-yard at Chatham, the descending motion of a large platform, on which timber is raised, is regulated by a governor; but as the weight is very considerable, the velocity of this governor is still farther checked by causing its motion to take place in water.

The regularity of the supply of fuel to the fire under the boilers of steam-engines is another mode of contributing to the uniformity of their rate, and also economizes the consumption of coal. Several patents have been taken out for methods of regulating this supply: the general principle being to make the engine supply the fire by means of a hopper, with small quantities of fuel at regular intervals, and to diminish this supply when it works quickly. One of the incidental advantages of this plan is, that by throwing on a very small quantity of coal at a time, the smoke is almost entirely consumed. The dampers of ash-pits and chimneys are also, in some cases, connected with machines in order to regulate their speed.

23. Another contrivance for regulating the effect of machinery consists in a vane or a fly, of little weight, but presenting a large surface. This revolves rapidly, and soon acquires a uniform rate, which it cannot greatly exceed, because any addition to its velocity produces a much greater addition to the resistance it meets with from the air. The interval between the strokes on the bell of a clock is regulated by this means; and the fly is so contrived, that this interval may be altered by presenting the arms of it more or less obliquely to the direction in which they move. This kind of fly, or vane, is generally used in the smaller kinds of mechanism, and, unlike the heavy fly, it is a destroyer instead of a preserver of force. It is the regulator used in musical boxes, and in almost all mechanical toys.

24. Another very beautiful contrivance for regulating the number of strokes made by a steam-engine, is used in Cornwall: it is called the *cataract*, and depends on the time required to fill a vessel plunged in water, the opening of the valve through which the fluid is admitted being adjustable at the will of the engine-man.

INCREASE AND DIMINUTION OF VELOCITY.

25. The fatigue produced on the muscles of the human frame does not altogether depend on the actual force employed in each effort, but partly on the frequency with which it is exerted. The exertion necessary to accomplish every operation consists of two parts: one of these is the expenditure of force which is necessary to drive the tool or instrument; and the other is the effort required for the motion of some limb of the animal producing the action. If we take, as an example, the act of driving a nail into a piece of wood, the first of these is the *propelling* the hammer head against the nail; the other is, *raising* the arm in order to lift the hammer. If the weight of the hammer is considerable, the former part will cause the great-

est portion of the exertion. If the hammer is light, the exertion of *raising* the arm will produce the greatest part of the fatigue. It does, therefore, happen that operations requiring very trifling force, if frequently repeated, will tire more effectually than more laborious work. There is also a degree of rapidity beyond which the action of the muscles cannot be pressed.

26. The most advantageous load for a porter who carries wood up stairs on his shoulders, has been investigated by M. Coulomb; but he found from experiment that a man walking up stairs without any load, and raising his burden by means of his own weight in descending, could do as much work in one day as four men employed in the ordinary way with the most favorable load.

27. The proportion between the velocity with which men or animals move, and the weights they carry, is a matter of considerable importance, particularly in military affairs. It is also of great importance for the economy of labor, to adjust the weight of that part of the animal's body which is moved, the weight of the tool it urges, and the frequency of repetition of these efforts, so as to produce the greatest effect. An instance of the saving of time, by making the same motion of the arm execute two operations instead of one, occurs in the simple art of making the tags of boot-laces: they are formed out of very thin, tinned, sheet-iron, and were formerly cut out of long strips of that material into pieces of such a breadth that when bent round they just enclosed the lace. Two pieces of steel have recently been fixed to the side of the shears, by which each piece of tinned-iron, as soon as it is cut, is bent into a semi-cylindrical form. The additional power required for this operation is almost imperceptible; and it is executed by the same motion of the arm which produces the cut. The work is usually performed by women and children, and with the improved tool more than three times the quantity of tags is produced in a given time.*

Whenever the work is itself light, it becomes necessary, in order to economize time, to increase the velocity. Twisting the fibres of wool by the fingers would be a most tedious operation: in the common spinning-wheel the velocity of the foot is moderate, but by a very simple contrivance that of the thread is most rapid. A piece of cat-gut passing round a large wheel, and then round a small spindle, effects this change. This contrivance is common to a multitude of machines, some of them very simple. In large shops for the retail of ribands, it is necessary at short intervals to "take stock," that is, to measure and re-wind every piece of riband, an operation which, even with this mode of shortening it, is sufficiently tiresome, but without it would be almost impossible from its expense. The small balls of sewing-cotton, so cheap and so beautifully wound, are formed by a machine on the same principle, and but a few steps more complicated.

28. In turning from the smaller instruments in frequent use to the larger and more important machines, the economy arising from the increase of velocity becomes more striking. In converting cast into wrought iron, a mass of metal of about a hundred weight is heated almost to a white heat, and placed under a heavy hammer moved by water or steam power. This is raised by a projection on a revolving axis; and if the hammer derived its momentum only from the space through which it fell, it would require a considerably greater time to give a blow. But as it is important that the softened mass of red hot iron should receive as many blows as possible before it cools, the form of the cam or projection on the axis is such, that, the hammer, instead of being lifted to a small height, is thrown up with a jerk, and almost the instant after it strikes against a large beam, which acts as a powerful spring, and drives it down on the iron, with such velocity that by these means about double the number of strokes can be made in a given time. In the smaller tilt-hammers, this is carried still farther: by striking the tail of the tilt-hammer forcibly against a small steel anvil, it rebounds with such velocity that from three to five hundred strokes are made in a minute.

29. In the manufacture of scythes, the length of the blade renders it necessary that the workman should move readily, so as to bring every part on the anvil in quick succession. This is effected by placing him in a seat suspended by ropes from the ceiling: so that he is enabled, with little bodily exertion, by pressing his feet against the block which supports the anvil, to vary his distance to any required extent. In the manufacture of anchors, an art in which this contrivance is of still greater importance, it has only been recently applied.

30. The most frequent reason for employing contrivances for diminishing velocity arises from the necessity of overcoming great resistances with small power. Systems of pulleys, the crane, and many other illustrations, might also here be adduced; but they belong more appropriately to some of the other causes, which we have assigned for the advantages of machinery. The common smoke-jack is an instrument in which the velocity communicated is too great for the purpose required: and it is transmitted through wheels which reduce it to a more moderate rate.

EXTENDING THE TIME OF ACTION OF FORCES.

31. This is one of the most common and most useful of the employments of machinery. The half minute which we daily devote to the winding up of our watches is an exertion of labor almost insensible, yet by the aid of a few wheels its effect is spread over the whole twenty-four hours. In our clocks, this extension of the time of action of the original force impressed is

* Transactions of the Society of Arts, 1826.

carried still farther; the better kind usually require winding up once in eight days, and some are occasionally made to continue in action during a month or even a year. Another familiar illustration may be noticed in our domestic furniture; the common jack, by which our meat is roasted, is a contrivance to enable the cook in a few minutes to exert a force which the machine retails out during the succeeding hour in turning the loaded spit, thus enabling her to bestow her undivided attention on the other important duties of her vocation. A great number of automatons, and mechanical toys moved by springs, may be classed under this division.

32. A small moving power, in the shape of a jack or a spring with a train of wheels, is often of great convenience to the experimental philosopher, and has been used with advantage in magnetic and electric experiments, where the rotation of a disk of metal or other body is necessary, thus allowing to the inquirer the unimpeded use of both his hands. A vane connected by a train of wheels, and set in motion by a heavy weight, has also on some occasions been employed in chemical processes, to keep a solution in a state of agitation. Another object, to which a similar apparatus may be applied, is the polishing of small specimens of minerals for optical experiments.

SAVING TIME IN NATURAL OPERATIONS.

33. The process of tanning will furnish us with a striking illustration of the power of machinery in accelerating certain processes in which natural operations have a principal effect. The object of this art is to combine a certain principle called *tanning* with every particle of the skin to be tanned. This in the ordinary process is accomplished by allowing the skins to soak in pits containing a solution of tanning matter: they remain in the pits six, twelve, or eighteen months; and in some instances, (if the hides are very thick,) they are exposed to the operation for two years, or even during a longer period. This length of time is apparently required in order to allow the tanning matter to penetrate into the interior of a thick hide. The improved process consists in placing the hides with the solution of tan in close vessels, and then exhausting the air. The consequence of this is to withdraw any air which might be contained in the pores of the hides, and to employ the pressure of the atmosphere to aid capillary attraction in forcing the tan into the interior of the skins. The effect of the additional force thus brought into action can be equal only to one atmosphere, but a farther improvement has been made: the vessel containing the hides is, after exhaustion, filled up with a solution of tan; a small additional quantity is then injected with a forcing-pump. By these means any degree of pressure may be given which the containing vessel is capable of supporting; and it has been found that, by employing such a method, the thickest hides may be tanned in six weeks or two months.

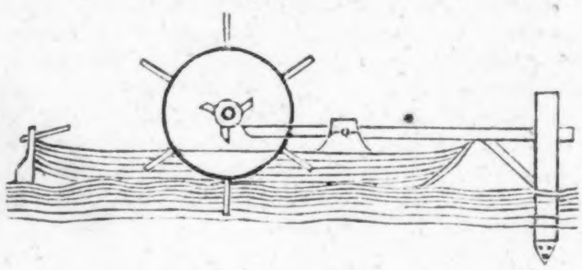
34. The same process of injection might be applied to impregnate timber with tar, or any other substance adapted to preserve it from decay; and if it were not too expensive, the deal floors of houses might thus be impregnated with alumine or other substances, which would render them much less liable to be accidentally set on fire. Some idea of the quantity of matter which can be injected into wood, by great pressure, may be formed from considering the fact stated by Mr. Scoresby, respecting an accident which occurred to a boat of one of our whaling-ships. The line of the harpoon being fastened to it, the whale in this instance dived directly down, and carried the boat along with him. On returning to the surface the animal was killed, but the boat, instead of rising, was found suspended beneath the whale by the rope of the harpoon; and on drawing it up, every part of the wood was found to be so completely saturated with water as to sink immediately to the bottom.

35. The operation of bleaching linen in the open air is one for which considerable time is necessary; and although it does not require much labor, yet, from the risk of damage and of robbery from long exposure, a mode of shortening the process was highly desirable. The method now practised, although not mechanical, is such a remarkable instance of the application of science to the practical purposes of manufactures, that in mentioning the advantages derived from shortening natural operations, it would have been scarcely pardonable to have omitted all allusion to the beautiful application of chlorine, in combination with lime, to the art of bleaching.

36. Another instance more strictly mechanical occurs in some countries where fuel is expensive, and the heat of the sun is not sufficient to evaporate the water from brine springs. The water is first pumped up to a reservoir, and then allowed to fall in small streams through faggots. Thus it becomes divided; and, presenting a large surface, evaporation is facilitated, and the brine which is collected in the vessels below the faggots is stronger than that which was pumped up. After thus getting rid of a large part of the water, the remaining portion is driven off by boiling. The success of this operation depends on the circumstance of the atmosphere not being saturated with moisture: if the air, at the time the brine falls through the faggots, holds in solution as much moisture as it can contain in an invisible state, none can be absorbed from the salt water, and the labor expended in pumping is entirely wasted. The state of the air, as to dryness, is therefore an important consideration in fixing the time when this operation is to be performed; and an attentive examination of its state, by means of the hygrometer, might be productive of some economy of labor.

37. In some countries, where wood is scarce, the evaporation of salt water is carried on by a large collection of ropes, which are stretched perpendicularly. The water passing down them deposites the sulphate of lime which it held in solution, and gradually incrusts the ropes, so that in the course of twenty years, when they are nearly rotten, they are sustained by the surrounding incrustation, thus presenting the appearance of a vast collection of small columns.

38. Amongst natural operations perpetually altering the surface of our globe, there are some which it would be advantageous to accelerate. The wearing down of the rocks which impede the rapids of navigable rivers is one of this class. A very beautiful process for accomplishing this object has been employed in America. A boat is placed at the bottom of the rapid, and kept in its position by a long rope, which is firmly fixed on the bank of the river near the top. An axis, having a wheel similar to the paddle-wheel of a steamboat fixed at each end of it, is placed across the boat; so that the two wheels and their connecting axis shall revolve rapidly, being driven by the force of the passing current. Let us now imagine several beams of wood shod with pointed iron fixed at the ends of strong levers, projecting beyond the bow of the boat, as in the annexed representation:



If these levers are at liberty to move up and down, and if one or more projecting pieces, called cams, are fixed on the axis opposite to the end of each lever, the action of the stream upon the wheels will keep up a perpetual succession of blows. The sharp-pointed shoe, striking upon the rock at the bottom, will continually detach small pieces, which the stream will immediately carry off. Thus, by the mere action of the river itself, a constant and most effectual system of pounding the rock at its bottom is established. A single workman may, by the aid of a rudder, direct the boat to any required part of the stream; and when it is necessary to move up the rapid, as the channel is cut, he can easily cause the boat to advance by means of a capstan.

39. When the object of the machinery just described has been accomplished, and the channel is sufficiently deep, a slight alteration converts the apparatus to another purpose almost equally advantageous. The stampers and the projection pieces on the axis are removed, and a barrel of wood or metal, surrounding part of the axis, and capable, at pleasure, of being connected with or disconnected from the axis itself, is substituted. The rope which hitherto fastened the boat is now fixed to this barrel; and if the barrel is loose upon the axis, the paddle-wheels make the axis only revolve, and the boat remains in its place: but the moment the axis is attached to its surrounding barrel, this begins to turn, and winding the rope upon itself, the boat is gradually drawn up against the stream, and may be employed as a kind of tug-boat for all the vessels which have occasion to ascend the rapid. When the tug-boat reaches the summit, the barrel is released from the axis, and friction being applied to moderate its velocity, the boat is allowed to descend.

EXERTING FORCES TOO GREAT FOR HUMAN POWER, AND EXECUTING OPERATIONS TOO DELICATE FOR HUMAN TOUCH.

40. It requires some skill and a considerable apparatus to enable many men to exert their whole force at a given point, and when this number amounts to hundreds or to thousands, additional difficulties present themselves. If ten thousand men were hired to act simultaneously, it would be exceedingly difficult to discover whether each exerted his whole force, and, consequently, to be assured that each man did the duty for which he was paid. And if still larger bodies of men or animals were necessary, not only would the difficulty of directing them become greater, but the expense would increase from the necessity of transporting food for their subsistence.

The difficulty of enabling a large number of men to exert their force at the same instant of time has been almost obviated by the use of sound. The whistle of the boatswain occasionally performs this service; and in removing, by manual force, the vast mass of granite, weighing above 1400 tons, on which the equestrian figure of Peter the Great is placed at St. Petersburg, a drummer was always stationed on its summit to give the signal for the united efforts of the workmen.

An interesting discovery was made a few years since, by Champollion, of an ancient Egyptian drawing, in which a multitude of men appeared harnessed to a huge block of stone, on the top of which stood a single individual with his hands raised above his head, apparently in the act of clapping them, for the same purpose of insuring the exertion of their combined force at the same moment of time.

41. In all our larger manufactories numerous instances occur of the application of the power of steam to overcome resistances which it would require far greater expense to surmount by means of animal labor. The twisting of the largest cables, the rolling, hammering, and cutting large masses of iron, the draining of our mines, all require enormous exertions of physical force continued for considerable periods of time. Other means are had recourse to

when the force required is great, and the space through which it is to act is small. The hydraulic press of Bramah can, by the exertion of one man, produce a pressure of 1500 atmospheres, and with such an instrument a hollow cylinder of wrought iron, three inches thick, has been burst. In riveting together the iron plates out of which steam engine boilers are made, it is necessary to produce as close a joint as possible. This is accomplished by using the rivets red-hot; while they are in that state the two plates of iron are rivetted together, and the contraction which the rivet undergoes in cooling draws them together with a force which is only limited by the tenacity of the metal of which the rivet itself is made.

42. It is not alone in the greater operations of the engineer or the manufacturer, that those vast powers which man has called into action, in availing himself of the agency of steam, are fully developed. Wherever the individual operation demanding little force for its own performance is to be multiplied in almost endless repetition, commensurate power is required. It is the same "giant arm which twists the largest cable," that spins from the cotton plant an "almost gossamer thread." Obedient to the hand which called into action its resistless powers, it contends with the ocean and the storm, and rides triumphantly through dangers and difficulties unattempted by the older modes of navigation. It is the same engine that, in its more regulated action, weaves the canvass it may one day supersede; or, with almost fairy fingers, entwines the meshes of the most delicate fabric that adorns the female form.*

43. The Fifth Report of the Select Committee of the House of Commons on the Holyhead Roads furnishes ample proof of the great superiority of steam vessels. The following extracts are taken from the evidence of Captain Rogers, the commander of one of the packets:

"*Question.*—Be so good as to acquaint the Committee in what manner the communication has been kept open between Holyhead and Dublin by steam packets, and what has been the success of the experiment of establishing them on that station.

"*Answer.*—We have done every thing that could be done, *by steamboats;* and they will go, no doubt, when a sailing vessel will not—that has been proved.

"*Question.*—Are you not perfectly satisfied, from the experience you have had, that the steam vessel you command is capable of performing what no sailing vessel can do?

"*Answer.*—Yes.

"*Question.*—During your passage from Gravesend to the Downs, could any square-rigged vessel, from a first-rate down to a sloop of war, have performed the voyage you did in the time you did it in the steamboat?

"*Answer.*—No; it was impossible. In the Downs we passed several Indiamen, and 150 sail, there, that could not move down the Channel; and at the back of Dungeness we passed 120 more.

"*Question.*—At the time you performed that voyage, with the weather you have described, from the Downs to Milford, if that weather had continued twelve months, would any square-rigged vessel have performed it?

"*Answer.*—They would have been a long time about it; probably would have been weeks instead of days. A sailing vessel would not have beat up to Milford, as we did, in twelve months."

44. The process of printing on silver paper, which is necessary for bank-notes, is attended with some inconvenience, from the necessity of damping the paper previously to taking the impression. It was difficult to do this uniformly; and in the process of dipping a parcel of several sheets together into a vessel of water, the outside sheets becoming much more wet than the others, were very apt to be torn. A method has been adopted at the Bank of Ireland which obviates this inconvenience. The whole quantity of paper to be damped is placed in a close vessel, from which the air is exhausted; water is then admitted, and every leaf is completely wetted; the paper is then removed to a press, and all the superfluous moisture is squeezed out.

REGISTERING OPERATIONS.

45. One of the most singular advantages we derive from machinery is in the check which it affords against the inattention, the idleness, or the knavery, of human agents. Few occupations are more wearisome than counting a series of repetitions of the same fact; the number of paces we walk affords a tolerably good measure of distance passed over, but the value of this is much enhanced by possessing an instrument, the pedometer, which will count for us the number of steps we have made. A piece of mechanism of this kind is sometimes applied to count the number of turns made by the wheel of a carriage, and thus to indicate the distance travelled: an instrument similar in its object, but differing in its construction, has been used for counting the number of strokes made by a steam-engine, and the number of coins struck in a press. One of the simplest instruments for counting any series of operations was contrived by Mr. Donkin.*

46. Another instrument for registering is used in some establishments for calendering and embossing. Many hundred thousand yards of calico and stuffs pass weekly through these operations, and as the price paid for the process is small, the value of the time spent in measur-

* The importance and diversified applications of the steam engine were most ably enforced in the speeches made at a public meeting, held (June, 1824) for the purpose of proposing the erection of a monument to the memory of James Watt; these were subsequently printed.

* Transactions of the Society of Arts, 1819. p. 116.

ing them would bear a considerable proportion to the profit. A machine has, therefore, been contrived for measuring and registering the length of the goods as they pass rapidly through the hands of the operator, and all chance of erroneous counting is thus avoided.

47. Perhaps the most useful contrivance of this kind is one for ascertaining the vigilance of a watchman. It is a piece of mechanism connected with a clock placed in an apartment to which the watchman has not access, but he is ordered to pull a string situated in a certain part of his round once in every hour. The instrument, aptly called a *tell-tale*, informs the owner whether the man has missed any, and what hours during the night.

48. It is often of great importance, both for regulations of excise as well as for the interests of the proprietor, to know the quantity of spirits or of other liquors which have been drawn off by those persons who are allowed to have access to the vessels during the absence of the inspectors or principals. This may be accomplished by a peculiar kind of stopcock, which will, at each opening, only discharge a certain measure of fluid,—the number of times the cock has been turned being registered by a counting apparatus, accessible only to the master.

49. The time and labor consumed in guaging casks partly filled has led to an improvement, which, by the simplest means, obviates a considerable inconvenience, and enables any person to read off, on a scale, the number of gallons contained in any vessel, as readily as he does the degree of heat indicated by his thermometer. A small stop-cock is inserted near the bottom of the cask, which it connects with a glass tube of narrow bore fixed to a scale on the side of the cask, and rising a little above its top. The plug of the cock may be turned into three positions: in the first it cuts off all communication with the cask; in the second, it opens a communication between the cask and the glass tube; and, in the third, it cuts off the connection between the cask and the tube, and opens a communication between the tube and any vessel held beneath the cock to receive its contents. The scale of the tube is graduated by opening the communication between the cask and tube, and pouring into the cask a gallon of water. A line is then drawn on the scale opposite the place in the tube to which the water rises. This operation is repeated, and at each successive gallon a new line is drawn. Thus the scale being formed by actual measurement,* both the proprietor and the excise officer see, on inspection, the contents of each cask, and the tedious process of guaging is altogether dispensed with. Other advantages accrue from this simple contrivance, in the great economy of time which it produces in making mixtures of different spirits in taking stock, and in receiving spirit from the distiller.

50. The gas-meter, by which the quantity of gas used by each consumer is ascertained, is another instrument of this kind. They are of several forms, but all of them intended to register the number of cubic feet of gas which has been delivered. It is very desirable that these meters should be obtainable at a moderate price, and that every consumer should employ them; because, by making each purchaser pay only for what he consumes, and by preventing that extravagant waste of gas which we frequently observe, the manufacturer of gas will be enabled to make an equal profit at a diminished price to the consumer.

51. The sale of water, by the different companies in London, might also, with advantage, be regulated by a different kind of meter. If such a system were adopted, much water which is now allowed to run to waste would be saved, and an unjust inequality between the rates charged on different houses by the same company be avoided.

52. Another subject to which machinery for registering operations is applied with much advantage is the determination of the average effect of natural or artificial agents. The mean height of the barometer, for example, is ascertained by noting its height at a certain number of intervals during the twenty-four hours. The more these intervals are contracted, the more correctly will the mean be ascertained; but the true mean ought to participate in each momentary change which has occurred. Clocks have been proposed and made for this purpose, and the principle adopted has been that of moving a sheet of paper, slowly and uniformly, before a pencil fixed to a float upon the surface of the mercury in the cup of the barometer. Sir David Brewster proposed, several years ago, to suspend a barometer, and swing it as a pendulum. The variations in the atmosphere would thus alter the centre of oscillation, and the comparison of such an instrument with a good clock would enable us to ascertain the mean altitude of the barometer during any interval of the observer's absence.*

Instruments might also be contrived to determine the average force of traction of horses—of the wind—of a stream—or of any other irregular and fluctuating effort of animal or natural force.

53. There are several instruments contrived for awakening the attention of the observer at times previously fixed upon. The various kinds of alarums connected with clocks and watches are of this kind. In some instances it is desirable to be able to set them so as to give notice at many successive and distant

* This contrivance is due to Mr. Henneky, of High Holborn, in whose establishment it is in constant employment.

* About seven or eight years since, without being aware of Sir David Brewster's proposal, I adapted a barometer as a pendulum to the works of a common eight-day clock; it remained in my library for several months, but I have mislaid the observations which were made.

points of time, such as those of the arrival of given stars on the meridian. A clock of this kind is used at the Royal Observatory at Greenwich.

Repeating clocks and watches may be considered as instruments for registering time, which communicate their information only when the owner requires it, by pulling a string, or by some similar application.

ECONOMY OF THE MATERIALS EMPLOYED.

54. The precision with which all operations by machinery are executed, and the exact similarity of the articles thus made, produce a degree of economy in the consumption of the raw material, which is in some cases of great importance. The earliest mode of cutting the trunks of a tree into planks was by the use of the hatchet or the adze. It might, perhaps, be first split into three or four portions, and then each portion was reduced to a uniform surface by those instruments. With such means the quantity of plank produced would probably not equal the quantity of the raw material wasted by the process; and, if the planks were thin, would certainly fall far short of it. An improved tool, the saw, completely reverses the case: in converting a tree into thick planks it causes a waste of a very small fractional part; and even in reducing it to planks of only an inch in thickness, it does not waste more than an eighth part of the raw material. When the thickness of the plank is still farther reduced, as is the case in cutting wood for veneering, the quantity of material destroyed again begins to bear a considerable proportion to that which is used; and, hence, circular saws, having a very thin blade, have been employed for such purposes. In order to economize still farther the more valuable woods, Mr. Brunel contrived a machine which, by a system of blades, cuts off the veneer in a continuous shaving, thus rendering the whole of the piece of timber available.

55. The rapid improvements which have taken place in the printing press during the last twenty years afford another instance of saving in the materials consumed, which is interesting from its connection with literature, and valuable because admitted and well ascertained by measurement. In the old method of inking type, by large hemispherical balls, stuffed and covered with leather, the printer, after taking a small portion of ink from the ink-block, was continually rolling them in various directions against each other, in order that a thin layer of ink might be uniformly spread over their surface. This he again transferred to the type by a kind of rolling action. In such a process, even admitting considerable skill in the operator, it could not fail to happen that a large quantity of ink should get near the edges of the balls, which, not being transferred to the type, became hard and useless, and was taken off in the form of a thick black crust. Another inconvenience also arose—the quantity of ink spread on the block not being regulated by measure, and the number and direction of the transits of the inking-balls over each other depending on the will of the operator, and being irregular, it was impossible to place on the type a uniform layer of ink, of exactly the quantity sufficient for the impression. The introduction of cylindrical rollers of an elastic substance, formed by the mixture of glue and treacle, superseded the inking-balls, and produced considerable saving in the consumption of ink: but the most perfect economy was only to be produced by mechanism. When printing presses, moved by the power of steam, were introduced, the action of these rollers was found well adapted to the performance of the machine; and a reservoir of ink was formed, from which one roller regularly abstracted a small quantity at each impression. From three to five other rollers spread this portion uniformly over a slab, (by most ingenious contrivances varied in almost each kind of press,) and another travelling roller, having fed itself on the slab, passed and repassed over the type just before it gave the impression to the paper.

The following is an account of the results of an accurate experiment upon the effect of the process just described, made at one of the largest printing establishments in the metropolis.* Two hundred reams of paper were printed off, the old method of inking with balls being employed; two hundred reams of the same paper, and for the same book, were then printed off in the presses which inked their own type. The consumption of ink by the machine was to that by the balls as *four to nine*, or rather less than one half. In order to show that this plan of inking puts the proper quantity of ink upon the type, we must prove, first,—that it is not too little: this would soon have been discovered from the complaints of the public and the booksellers; and, secondly,—that it is not too much. This latter point is satisfactorily established by a reference to the frequency of the change of what is called the *set-off sheet*, in the old method. A few hours after one side of a sheet of paper has been printed upon, the ink is sufficiently dry to allow it to receive the impression upon the other; and, as considerable pressure is made use of, the tympan on which the side first printed is laid, is guarded from soiling it by a sheet of paper called the *set-off sheet*. This paper receives in succession every sheet of the work to be printed, and acquires from them more or less of the ink, according to their dryness, or the quantity upon them. It was necessary in the former process, after about one hundred impressions, to change the *set-off sheet*, which in that time became too much soiled for farther use. In the new method of printing by machinery, no *set-off sheet* is used, but a blanket

* This experiment was made at the establishment of Mr. Clowes, in Stamford street.

is employed as its substitute; this does not require changing above once in five thousand impressions, and instances have occurred of its remaining sufficiently clean for twenty thousand. Here, then, is a proof that the quantity of superfluous ink put upon the paper in machine-printing is so small, that if multiplied by five thousand, and in some instances even by twenty thousand, it is only sufficient to render useless a single piece of clean cloth.*

OF THE IDENTITY OF THE WORK WHEN IT IS OF THE SAME KIND, AND ITS ACCURACY WHEN OF DIFFERENT KINDS.

56. Nothing is more remarkable, and yet less unexpected, than the perfect identity of things manufactured by the same tool. If the top of a circular box is to be made to fit over the lower part, it may be done in the lathe by gradually advancing the tool of the sliding-rest; the proper degree of tightness between the box and its lid being found by trial. After this adjustment, if a thousand boxes are made, no additional care is required; the tool is always carried up to the stop, and each box will be equally adapted to every lid. The same identity pervades all the arts of printing; the impressions from the same block, or the same copper-plate, have a similarity which no labor could produce by hand. The minutest traces are transferred to all the impressions, and no omission can arise from the inattention or unskilfulness of the operator. The steel punch, with which the card-wadding for a fowling-piece is cut, if it once perform its office with accuracy, constantly reproduces the same exact circle.

57. The accuracy with which machinery executes its work is, perhaps, one of its most important advantages; it may, however, be contended, that a considerable portion of this advantage may be resolved into saving of time, for it generally happens, that any improvement in tools increases the quantity of work done in a given time. Without tools, that is, by the mere efforts of the human hand, there are, undoubtedly, multitudes of things which it would be impossible to make. Add to the human hand the rudest cutting instrument, and its powers are enlarged; the fabrication of many things then becomes easy, and that of others possible with great labor. Add the saw to the knife or the hatchet, and other works become possible, and a new course of difficult operations is brought into view, whilst many of the former are rendered easy. This observation is applicable even to the most perfect tools or machines. It would be *possible* for a very skilful workman, with files and polishing substances, to form a cylinder out of a piece of steel; but the time which this would require would be so considerable, and the number of failures would probably be so great, that for all practical purposes such a mode of producing a steel cylinder might be said to be impossible. The same process, by the aid of the lathe and the sliding-rest, is the every-day employment of hundreds of workmen.

58. Of all the operations of mechanical art, that of turning is the most perfect. If two surfaces are worked against each other, whatever may have been their figure at the commencement, there exists a tendency in them both to become portions of spheres. Either of them may become convex, and the other concave, with various degrees of curvature. A plane surface is the line of separation between convexity and concavity, and is most difficult to hit; and it is more easy to make a good circle than to produce a straight line. A similar difficulty takes place in figuring specula for telescopes; the parabola is the surface which separates the hyperbolic from the elliptic figure, and is the most difficult to form. If a spindle, not cylindrical at its end, is pressed into a hole not circular, and if the spindle be kept constantly turning, there is a tendency in these two bodies so situated to become conical, or to have circular sections. If a triangular pointed piece of iron be worked round in a circular hole, the edges will gradually wear, and it will become conical. These facts, if they do not explain, at least illustrate the principles on which the excellence of work formed in the lathe depends.

OF COPYING.

59. The two last sources of excellence in the work produced by machinery depend on a principle which pervades a very large portion of all manufactures, and is one upon which the cheapness of the articles produced seems greatly to depend. The principle alluded to is that of COPYING, taken in its most extensive sense. Almost unlimited pains are, in some instances, bestowed on the original, from which a series of copies is to be produced; and the larger the number of these copies, the more care and pains can the manufacturer afford to lavish upon the original. It may thus happen, that the instrument or tool actually producing the work shall cost five or even ten thousand times the price of each individual specimen of its power.

As the system of copying is of so much importance, and of such extensive use in the arts, it will be convenient to classify a considerable number of those processes in which it is employed. The following enumeration is not offered as a complete list; and the explanations are restricted to the shortest possible detail which is consistent with a due regard to making the subject intelligible. Operations of copying are effected under the following circumstances:

By printing from cavities.	By stamping.
By printing from surface.	By punching.
By casting.	With elongation.
By moulding.	With altered dimensions.

OF PRINTING FROM CAVITIES.

60. The art of printing, in all its numerous

* In the very best kind of printing, it is necessary, in the old method, to change the set-off sheet once in twelve times. In printing the same kind of work by machinery the blanket is changed once in 2000.

departments, is essentially an art of copying. Under its two great divisions, printing from hollow lines, as in copper-plate, and printing from surface, as in block printing, are comprised numerous arts.

61. *Copper-plate Printing.*—In this instance the copies are made by transferring to paper, by means of pressure, a thick ink, from the hollows and lines cut in the copper. An artist will sometimes exhaust the labor of one or two years upon engraving a plate, which will not, in some cases, furnish above five hundred copies in a state of perfection.

62. *Engraving on Steel.*—This is an art in most respects similar to engraving on copper, except that the number of copies is far less limited. A bank note engraved as a copper-plate will not give above three thousand impressions without a sensible deterioration. Two impressions of a bank note engraved on steel were examined by one of our most eminent artists,* who found it difficult to pronounce with any confidence which was the earliest impression. One of these was a proof from amongst the first thousand, the other was taken after between seventy and eighty thousand had been printed off.

63. *Music Printing.*—Music is usually printed from pewter-plates, on which the characters have been impressed by steel punches. The metal being much softer than copper is liable to scratches, which detain a small portion of the ink. This is the reason of the dirty appearance of printed music. A new process has recently been invented by Mr. Cowper, by which this inconvenience will be avoided. The improved method, which gives sharpness to the characters, is still an art of copying; but it is effected by surface-printing, nearly in the same manner as calico-printing, from blocks, to be described hereafter, (70.) The method of printing music from pewter-plates, although by far the most frequently made use of, is not the only one employed, for music is occasionally printed from stone. Sometimes also it is printed with moveable type; and occasionally the musical characters are printed on the paper, and the lines printed afterwards. Specimens of both these latter modes of music printing may be seen in the splendid collection of impressions from the types of the press of Bodoni at Parma: but notwithstanding the great care bestowed on the execution of that work, the perpetual interruption of continuity in the lines, arising from the use of moveable type, when the characters and lines are printed at the same time, is apparent.

64. *Calico-Printing from Cylinders.*—Many of the patterns on printed calicoes are copies by printing from copper cylinders about four or five inches in diameter, on which the desired pattern has been previously engraved. One portion of the cylinders is exposed to the ink, whilst an elastic scraper of stuffed leather, by being pressed forcibly against another part removes all superfluous ink from the surface previously to its reaching the cloth. A piece of calico twenty-eight yards in length rolls through this press, and is printed in four or five minutes.

65. *Printing from perforated Sheets of Metal, or Stencilling.*—Very thin brass is sometimes perforated in the form of letters, usually those of a name; this is placed on any substance which it is required to mark, and a brush dipped in paint is passed over the brass. Those parts which are cut away admit the paint, and thus a copy of the name appears on the substance below. This method, which affords rather a coarse copy, is sometimes used for paper with which rooms are covered, and more especially for the borders. If a portion is required to match an old pattern, this is, perhaps, the most economical way of producing it.

66. The beautiful red cotton handkerchiefs dyed at Glasgow have their pattern given to them by a process similar to this, except that, instead of *printing* from a pattern, the reverse operation—that of *discharging* a part of the color from a cloth already dyed—is performed. A number of handkerchiefs are pressed with very great force between two plates of metal, which are similarly perforated with round or lozenge-shaped holes, according to the intended pattern. The upper plate of metal is surrounded by a rim, and a fluid which has the property of discharging the red dye is poured upon that plate. This liquid passes through the holes in the metal, and also through the calico; but, owing to the great pressure opposite all the parts of the plates not cut away, it does not spread itself beyond the pattern. After this the handkerchiefs are washed, and the pattern of each is a copy of the perforated metal plate used in the process.

OF PRINTING FROM SURFACE.

This second department, of printing from surface, is of more frequent application in the arts than that which has just been considered.

67. *Printing from wooden Blocks.*— A block of box wood is in this instance the substance out of which the pattern is formed: the design being sketched upon it, the workman cuts away with sharp tools every part except the lines to be represented in the impression. This is exactly the reverse of the process of engraving on copper, in which every line to be represented is cut away. The ink, instead of filling the cavities cut in the wood, is spread upon the surface which remains, and is thence transferred to the paper.

68. *Printing from moveable Types.*—This is the most important in its influence, of all the arts of copying. It possesses a singular peculiarity in the immense subdivision of the parts that form the pattern. After that pattern has furnished thousands of copies, the same individual elements may be arranged again and

* The late Mr. Lowry.

again in other forms, and thus supply multitudes of originals, from each of which thousands of their copied impressions may flow.

69. *Printing from Stereotype.*—This mode of producing copies is very similar to the preceding; but as the original pattern is incapable of change, it is only applied to cases where an extraordinary number of copies are demanded, or where the work consists of figures, and it is of great importance to insure accuracy. Alterations may be made in it from time to time; and thus mathematical tables may, by the gradual extirpation of error, at last become perfect. This mode of producing copies possesses, in common with that by moveable types, the advantage of being capable of use in conjunction with wood cuts, a union frequently of considerable importance, and which is not so readily accomplished with engravings on copper.

70. *Calico-Printing from Blocks.*—This is a mode of copying, by surface-printing, from the ends of small pieces of copper wire, of various forms, fixed into a block of wood. They are all of one uniform height, about the eighth part of an inch above the surface of the wood, and are arranged by the maker into any required pattern. If the block be placed upon a piece of fine woollen cloth, on which ink of any color has been uniformly spread, the projecting copper wires receive a portion, which they give up when applied to the calico to be printed. By the former method of printing on calico, only one color could be used; but by this plan, after the flower of a rose, for example, has been printed with one set of blocks, the leaves may be printed of another color by a different set.

71. *Printing Oil-Cloth.*—After the canvass, which forms the basis of oil-cloth, has been covered with paint of one uniform tint, the remainder of the processes which it passes through is a series of copyings by surface-printing, from patterns formed upon wooden blocks very similar to those employed by the calico printer. Each color requires a distinct set of blocks, and thus those oil-cloths with the greatest variety of colors are most expensive.

There are several other varieties of printing which we shall briefly notice as arts of copying; which, although not strictly surface-printing, yet are more allied to it than to that from copper plates.

72. *Letter Copying.*—In one of the modes of performing this process, a sheet of very thin paper is damped, and placed upon the writing to be copied. The two papers are then passed through a rolling press, and a portion of the ink from one paper is transferred to the other. The writing is of course reversed by this process; but the paper to which it is transferred being thin, it is visible on the other side, in an uninverted position. Another common mode of copying letters is by placing a sheet of paper, covered on both sides with a substance prepared from lamp-black, between a sheet of thin paper and the paper on which the letter to be despatched is to be written. If the upper or thin sheet be written upon with any hard pointed substance, the words written with this style will be impressed from the black paper upon both those adjoining it. The translucency of the upper sheet, which is retained by the writer, is in this instance necessary to render legible the writing which is on the back of the paper. Both these arts are very limited in their extent, two or three being the utmost number of repetitions they allow.

73. *Printing on China.*—This is an art of copying which is carried to a very great extent. As the surfaces to which the impression is to be conveyed are often curved, and sometimes even fluted, the ink, or paint, is first transferred from the copper to some flexible substance, such as paper, or an elastic compound of glue and treacle. It is almost immediately conveyed from this to the unbaked biscuit, to which it more readily adheres.

74. *Lithographic Printing.*—This is another mode of producing copies in almost unlimited number. The original which supplies the copies is a drawing made on a stone of a slightly porous nature; the ink employed for tracing it is made of such greasy materials that when water is poured over the stone it shall not wet the lines of the drawing. When a roller covered with printing-ink, which is of an oily nature, is passed over the stone previously wetted, the water prevents this ink from adhering to the uncovered portions; whilst the ink used in the drawing is of such a nature that the printing-ink adheres to it. In this state, if a sheet of paper be placed upon the stone, and then passed under a press, the printing-ink will be transferred to the paper, leaving the ink used in the drawing still adhering to the stone.

75. There is one application of lithographic printing which does not appear to have received sufficient attention, and perhaps farther experiments are necessary to bring it to perfection. It is the reprinting of works which have just arrived from other countries. A few years ago one of the Paris newspapers was reprinted at Brussels as soon as it arrived, by means of lithography. Whilst the ink is yet fresh this may easily be accomplished: it is only necessary to place one copy of the newspaper on a lithographic stone; and by means of great pressure applied to it in a rolling press, a sufficient quantity of the printing-ink will be transferred to the stone. By similar means, the other side of the newspaper may be copied on another stone, and these stones will then furnish impressions in the usual way. If printing from stone could be reduced to the same price per thousand as that from moveable types, this process might be adopted with great advantage for the supply of works for the use of distant countries possessing the same language: for a single copy of the work might be printed off with *transfer ink*, which is better adapted to

this purpose; and thus an English work, for example, might be published in America from stone, whilst the original, printed from moveable types, made its appearance on the same day in England.

It is much to be wished that such a method were applicable to the reprinting of fac-similes of old and scarce books. This, however, would require the sacrifice of two copies, since a leaf must be destroyed for each page. Such a method of reproducing a small impression of an old work is peculiarly applicable to mathematical tables, the setting up of which in type is always expensive, and liable to error; but how long ink will retain its power of being transferred to stone from paper on which it has been printed, must be determined by experiment. The destruction of the greasy or oily portion of the ink in the character of old books seems to present the greatest impediment: if one constituent only of the ink were removed by time, it might perhaps be hoped that chemical means would ultimately be discovered for restoring it: but if this be unsuccessful, an attempt might be made to discover some substance having a strong affinity for the carbon of the ink which remains on the paper, and very little for the paper itself.*

76. *Register Printing.*—It is sometimes thought necessary to print from a wooden block, or stereotype plate, the same pattern reversed upon the opposite side of the paper. The effect of this, which is technically called *Register Printing*, is to make it appear as if the ink had penetrated through the paper, and rendered the pattern visible on the other side. If the subject chosen contains many fine lines, it seems at first sight extremely difficult to effect so exact a super-position of the two patterns, on opposite sides of the same piece of paper, that it shall be impossible to detect the slightest deviation; yet the process is extremely simple. The block which gives the impression is always accurately brought down to the same place by means of a hinge; this spot is covered by a piece of thin leather stretched over it; the block is now inked, and being brought down to its place, gives an impression of the pattern to the leather; it is then turned back; and being inked a second time, the paper intended to be printed is placed upon the leather, when the block again descending, the upper surface of the paper is printed from the block, and its under surface takes up the impression from the leather. It is evident that the perfection of this mode of printing depends in a great measure on finding some soft substance like leather, which will take as much ink as it ought from the block, and which will give it up most completely to paper. Impressions thus obtained are usually fainter on the lower side; and in order in some measure to remedy this defect, rather more ink is put on the block at the first than at the second impression.

OF COPYING BY CASTING.

77. The art of casting, by pouring substances in a fluid state into a mould which retains them until they become solid, is essentially an art of copying; the thing produced resembling entirely, as to shape, the pattern from which it was formed.

78. *Of Casting Iron and other Metals.*—Patterns of wood or metal made from drawings are the originals from which the moulds for casting are made: so that, in fact, the casting itself is a copy of the mould, and the mould is a copy of the pattern. In castings of iron and metals for the coarser purposes, and, if they are afterwards to be worked, even for the finer machines, the exact resemblance amongst the things produced, which takes place in many of the arts to which we have alluded, is not effected in the first instance, nor is this necessary. As the metals shrink in cooling, the pattern is made larger than the intended copy; and in extricating it from the sand in which it is moulded, some little difference will occur in the size of the cavity which it leaves. In smaller works, where accuracy is more requisite, and where few or no after operations are to be performed, a mould of metal is employed which has been formed with considerable care. Thus, in casting bullets, which ought to be perfectly spherical and smooth, an iron instrument is used in which a cavity has been cut and carefully ground: and in order to obviate the contraction in cooling, a *jet* is left which may supply the deficiency of metal arising from that cause, and which is afterwards cut off. The leaden toys for children are cast in brass moulds, which open, and in which have been graved or chiseled the figures intended to be produced.

79. A very beautiful mode of representing small branches of the most delicate vegetable productions in bronze has been employed by Mr. Chantrey. A small strip of a fir-tree, a branch of holly, a curled leaf of broccoli, or any other vegetable production, is suspended by one end in a small cylinder of paper which is placed for support within a similarly formed tin case: the finest river silt, carefully separated from all the coarser particles, and mixed with water so as to have the consistency of cream, is poured into the paper cylinder by small portions at a time, carefully shaking the plant a little after each addition, in order that its leaves may be covered, and that no bubbles of air may be left. The plant and its mould are now allowed to dry, and the yielding nature of the paper allows the loamy coating to shrink from the outside. When this is dry it is surrounded by a coarser substance; and, finally, we have the twig with all its leaves imbedded in a perfect mould. This mould is carefully dried, and then gradually heated to a red heat. At the ends of some of the [illegible]es or shoots,

* I possess a lithographic reprint of one page of a table, which appears from the form of the type, to have been several years old.

wires have been left to afford air-holes by their removal, and in this state of strong ignition a stream of air is directed into the hole formed by the end of the branch. The consequence is, that the wood and leaves which had been turned into charcoal by the fire, are now converted into carbonic acid by the current of air; and after some time the whole of the solid matter of which the plant consisted is completely removed, leaving a hollow mould, bearing on its interior all the minutest traces of its late vegetable occupant. When this process is completed, the mould, being still kept at nearly a red heat, receives the fluid metal, which, by its weight, either drives the very small quantity of air, which at that high temperature remains behind, out through the air-holes, or compresses it into the pores of the very porous substance of which the mould is formed.

80. *Casting in Plaster.*—This is a mode of copying applied to a variety of purposes: to produce accurate representations of the human form—of statues—or of rare fossils—to which latter purpose it has lately been applied with great advantage. In all casting, the first process is to make the mould; and plaster is the substance which is almost always employed for the purpose. The property which it possesses of remaining for a short time in a state of fluidity, renders it admirably adapted to this object, and adhesion, even to an original of plaster, is effectually prevented by oiling the surface on which it is poured. The mould formed round the subject which is copied, removed in separate pieces and then re-united, is that in which the copy is cast. This process gives additional utility and value to the finest works of art. The students of the Academy at Venice are thus enabled to admire the sculptured figures of Egina, preserved in the gallery at Munich; as well as the marbles of the Parthenon, the pride of our own Museum. Casts in plaster of the Elgin marbles adorn many of the academies of the Continent, and the liberal employment of such presents affords us an inexpensive and permanent source of popularity.

81. *Casting in Wax.*—This mode of copying, aided by proper coloring, offers the most successful imitations of many objects of natural history, and gives an air of reality to them which might deceive even the most instructed. Numerous figures of remarkable persons, having the face and hands formed in wax, have been exhibited at various times; and the resemblances have in some instances been most striking. But whoever would see the art of copying in wax carried to the highest perfection, should examine the beautiful collection of fruit at the house of the Horticultural Society; the model of the magnificent flower of the new genus Rafflesia; the waxen models of the internal parts of the human body, which adorn the anatomical gallery of the Jardin des Plantes at Paris, and the Museum at Florence—or the collection of morbid anatomy, at the University of Bologna. The art of imitation by wax does not usually afford the multitude of copies which flow from many similar operations. This number is checked by the subsequent stages of the process, which, ceasing to have the character of copying by a tool or pattern, become consequently more expensive. In each individual production, form alone is given by casting; the coloring must be the work of the pencil, guided by the skill of the artist.

OF COPYING BY MOULDING.

82. This method of producing multitudes of individuals having an exact resemblance in external shape, is adopted very widely in the arts. The substances employed are, either naturally or by artificial preparation, in a soft or plastic state; they are then compressed by mechanical force, sometimes assisted by heat, into a mould of the required form.

83. *Of Bricks and Tiles.*—An oblong box of wood fitting upon a bottom fixed to the brickmaker's bench, is the mould from which every brick is formed. A portion of the plastic mixture of which the bricks consist is made ready by less skilful hands; the workman first sprinkles a little sand into the mould, and then throws the clay into it with some force, at the same time rapidly working it with his fingers, so as to make it completely close up to the corners. He next scrapes off, with a wetted stick, the superfluous clay, and shakes the new-formed brick dexterously out of its mould upon a piece of board, on which it is removed by another workman to the place appointed for drying it. A very skilful moulder has, occasionally, in a long summer's day, delivered from ten to eleven thousand bricks; but a fair average day's work is from five to six thousand. Tiles of various kinds and forms are made of finer materials, but by the same system of moulding. Amongst the ruins of the city of Gour, the ancient capital of Bengal, are found bricks having projecting ornaments in high relief: these appear to have been formed in a mould, and subsequently glazed with a colored glaze. In Germany, also, brickwork has been executed with various ornaments. The cornice of the church of St. Stefano, at Berlin, is made of large blocks of brick moulded into the form required by the architect.

84. *Of Embossed China.*—Many of the forms given to those beautiful specimens of earthenware, which constitute the equipage of our breakfast and our dinner tables, are not capable of being executed in the lathe of the potter. The embossed ornaments on the edges of the plates, their polygonal shape, the fluted surface of many of the vases, would all be difficult and costly of execution by the hand; but they become easy and uniform in all their parts when made by pressing the soft material, out of which they are formed, into a hard mould. The care and skill bestowed on the preparation of that mould are repaid by the multitude it produces.

In many of the works of the china manufactory, one part only of the article is moulded—the upper surface of the plate, for example—whilst the under side is figured by the lathe. In some instances the handle, or only a few ornaments, are moulded, and the body of the work is turned.

85. *Glass Seals.*—The process of engraving upon gems is one requiring considerable time and skill. The seals thus produced can, therefore, never become common. Imitations, however, have been made of various degrees of resemblance. The color which is given to glass is, perhaps, the most successful part of the imitation. A small cylindrical rod of colored glass is heated in the flame of a blow-pipe, until the extremity becomes soft. The operator then pinches it between the ends of a pair of nippers, which are formed of brass, and on one side of which has been carved in relief the device intended for the seal. When care has been taken in heating the glass properly, and when the mould has been well finished, the seals thus produced are not bad imitations. By this system of copying they are so multiplied, that at Birmingham the more ordinary kinds are to be purchased at three-pence a dozen.

86. *Square Glass Bottles.*—The round forms which are usually given to vessels of glass are readily produced by the expansion of the air with which they are blown. It is, however, necessary in many cases to make bottles of a square form, and each capable of holding exactly the same quantity of fluid. It is also frequently desirable to have imprinted on them the name of the maker of the medicine or other liquid they are destined to contain. A mould of iron, or of copper, is provided, of the intended size, on the inside of which are engraved the names required. This mould, which is used in a hot state, opens into two parts, to allow the insertion of the round unfinished bottle, which is placed in it in a very soft state, before it is removed from the end of the iron tube with which it was blown. The mould is now closed, and by blowing strongly into the bottle the glass is forced against its sides.

87. *Wooden Snuff-Boxes.*—Snuff-boxes ornamented with devices, in imitation of carved work or of rose engine-turning, are sold at a price which proves that they are only imitations. The wood, or horn, out of which they are formed, is softened by long boiling in water, and whilst in this state it is forced in moulds of iron, or steel, on which are cut the requisite patterns, where it remains exposed to great pressure until it is dry.

88. *Horn Knife-Handles and Umbrella-Handles.*—The property which horn possesses of becoming soft by the action of water and heat, fits it for many useful purposes. It is pressed into moulds, and becomes embossed with figures in relief, adapted to the nature and use of the objects to which it is to be applied. If curved, it may be straightened; or if straight, it may be bent into any form which ornament or utility may require; and by the use of the mould these forms may be multiplied in endless variety. The commoner sorts of knives, the crooked handles for umbrellas, and a multitude of other articles to which horn is applied, attest the cheapness which the art of copying gives to the things formed of this material.

89. *Moulding Tortoise-Shell.*—The same principle is applied to things formed out of the shell of the turtle, or the land tortoise. From the greatly superior price of the raw material, this principle of copying is, however, more rarely employed upon it; and the few carvings which are demanded are usually performed by hand.

90. *Tobacco Pipe-Making.*—This simple art is almost entirely one of copying. The moulds are formed of iron, in two parts, each embracing one-half of the stem; the line of junction of these parts may generally be observed running lengthwise from one end of the pipe to the other. The hole passing to the bowl is formed by thrusting a long wire through the clay whilst it is enclosed in the mould. Some of the moulds have figures, or names, sunk in the inside. This gives a corresponding figure in relief upon the finished pipe.

91. *Embossing upon Calico.*—Calicoes of one color, but embossed all over with various raised patterns, although not much worn in this country, are in great demand in several foreign markets. This appearance is produced by passing them through a pair of rollers, on one of which is figured in intaglio the pattern to be transferred to the calico. The substance of the cloth is pressed very forcibly into the cavities thus formed, and preserves its figured appearance after considerable use.

92. *Embossing upon Leather.*—This art of copying from patterns previously engraved on steel rollers is, in most respects, similar to the preceding. The leather is forced into the cavities, and that part which is not opposite to any cavity is powerfully condensed between the rollers.

93. *Swaging.*—This is an art of copying practised by the smith. In order to fashion his iron and steel into the form demanded by his customers, he has small blocks of steel into which are sunk cavities of various shapes; these are called *swages*, and are generally in pairs. Thus, if he wants a round bolt, terminating in a cylindrical head of larger diameter, and having one or more projecting rims, he uses a corresponding *swaging-tool;* and having heated the end of his iron rod, and thickened it by a process which is technically called *upsetting*, he places its head upon one of the parts of the *swage;* and while an assistant holds the other part on the top of the hot iron, he strikes it several times with his hammer, occasionally turning the head one quarter round. The heated and softened iron is thus forced by the blows to assume the form of the mould into which it is impressed.

94. *Engraving by Pressure.*—This is one of

the most beautiful instances of the art of copying, carried to an almost unlimited extent; and the delicacy with which it can be executed, and the precision with which the finest traces of the graving tool can be transferred from steel to copper, or even from hard steel to soft steel, is most unexpected. We are indebted to Mr. Perkins for most of the contrivances which have brought this art at once almost to perfection. An engraving is first made upon soft steel, which is hardened by a peculiar process, without in the least injuring its delicacy. A cylinder of soft steel, pressed with great force against the hardened steel engraving, is now made to roll slowly backward and forward over it, thus receiving the design, but in relief. This is in its turn hardened without injury; and if it be slowly rolled to and fro with strong pressure on successive plates of copper, it will imprint on a thousand of them a perfect fac-simile of the original steel engraving from which it resulted. Thus the number of copies producible from the same design is multiplied a thousand-fold. But even this is very far short of the limits to which this process may be extended. The hardened steel-roller, bearing the design upon it in relief, may be employed to make a few of its first impressions upon plates of *soft steel*, and these being hardened become the representatives of the original engraving, and may in their turn be made the parents of other rollers, each generating copper-plates like their prototype. The possible extent to which fac-similes of one original engraving may thus be multiplied almost confounds the imagination, and appears to be for all practical purposes unlimited. There are two principles which peculiarly fit this art for rendering the forgery of bank notes (to prevent which it was proposed by Mr. Perkins) a matter of great difficulty. The first is the perfect identity of every impression with every other, so that any variation in the minutest line would at once cause detection. The other principle is, that the plates, from which all the impressions are derived, may be formed by the united labors of artists most eminent in their several departments; and as only one original of each design is necessary, the expense, even of the most elaborate engraving, will be trifling, compared with the multitude of copies produced from it.

95. It must, however, be admitted that the principle of copying itself furnishes an expedient for imitating any engraving or printed pattern, however complicated; and that it presents a difficulty which none of the schemes devised for the prevention of forgery appear to have yet effectually met. In attempting to imitate the most perfect bank note, the first process would be to place it with the printed side downwards, upon a stone or other substance, on which, by passing it through a rolling press, it might be firmly fixed. The next object would be to discover some solvent which should dissolve the paper, but neither affect the printing-ink nor injure the stone or substance on which it is impressed. Water does not seem to do this effectually, and perhaps weak alkaline or acid solutions would be tried. If, however, this could be fully accomplished, and if the stone or other substance used had those properties which enable us to print from it, then innumerable fac-similes of the note might be made, and the imitation would be complete. Porcelain biscuit, which has recently been used with a black lead pencil for memorandum books, seems, in some measure, adapted for such trials, since its porosity may be diminished to any extent by diminishing the dilution of the glazing applied to it.

96. *Gold and Silver Moulding.*—Many of the mouldings used by jewellers consist of thin slips of metal, which have received their form by passing between steel rollers, on which the pattern is embossed or engraved; thus taking a succession of copies of the devices intended.

97. *Ornamental Papers.*—Sheets of paper colored or covered with gold or silver leaf, and embossed with various patterns, are used for covering books, and for many ornamental purposes. The figures upon these are produced by the same process, that of passing the sheets of paper between engraved rollers.

OF COPYING BY STAMPING.

This mode of copying is extensively employed in the arts. It is generally executed by means of large presses worked with a screw and heavy fly-wheel. The materials on which the copies are impressed are most frequently metals, and the process is sometimes executed when they are hot, and in one case when the metal is in a state between solidity and fluidity.

98. *Coins and Medals.*—The whole of the coins which circulate as money are produced by this mode of copying. The screw-presses are either worked by manual labor, by water, or by steam power. The mint which was sent a few years since to Calcutta was capable of coining 200,000 pieces a day. Medals, which usually have their figures in higher relief than coins, are produced by similar means; but a single blow is rarely sufficient to bring them to perfection, and the compression of the metal which arises from the first blow renders it too hard to receive many subsequent blows without injury to the die. It is, therefore, after being struck, removed to a furnace, in which it is carefully heated red-hot and annealed, after which operation it is again placed between the dies; and receives additional blows. For large medals, and those on which the figures are very prominent, these processes must be repeated many times. One of the largest medals hitherto struck underwent them nearly a hundred times before it was completed.

99. *Ornaments for Military Accoutrements, and Furniture.*—These are usually made of brass, and are stamped up out of solid or sheet brass by placing it between dies, and allowing

a heavy weight to drop upon the upper die from a height of from five to fifteen feet.

100. *Buttons and Nail Heads.*—Buttons embossed with crests or other devices are produced by the same means; and some of those which are plain receive their hemispherical form from the dies in which they are struck. The heads of several kinds of nails which are portions of spheres, or polyhedrons, are also formed by these means.

101. *Of a Process for Copying, called in France Clichee.*—This curious method of copying by stamping is applied to medals, and in some cases to forming stereotype plates. There exists a range of temperature previous to the melting point, of several of the alloys of lead, tin, and antimony, in which the compound is neither solid, nor yet fluid. In this kind of pastry state it is placed in a box under a die, which descends upon it with considerable force. The blow drives the metal into the finest lines of the die, and the coldness of the latter immediately solidifies the whole mass. A quantity of the half melted metal is driven about by the blow in all directions, and is retained by the sides of the box in which the process is carried on. The work thus produced is admirable for its sharpness, but has not the finished form of a piece just leaving the coining-press; the sides are ragged, and it must be trimmed, and its thickness equalized in the lathe.

OF COPYING BY PUNCHING.

102. This mode of copying consists in driving, either by a blow or by pressure, a steel punch through the substance to be cut. In some cases the object is to make repeated copies of the same aperture, and the substance separated from the plate is rejected; in other cases it is the small pieces cut out which are the objects of the workman's labor.

103. *Punching Iron Plate for Boilers.*—The steel punch used for this purpose is from three-eighths to three-quarters of an inch in diameter, and drives out from a plate of iron a circular disk from one-fourth to five-eighths of an inch thick.

104. *Punching Tinned Iron.*—The ornamental patterns of open work, which decorate the tinned and japanned wares in general use, are rarely punched by the workman who makes them. In London, the art of punching out these patterns in screw-presses is carried on as a separate trade; and large quantities of sheet tin are perforated for cullenders, wine-strainers, borders of waiters, and other similar purposes. The perfection and regularity to which the art has been carried are remarkable. Sheets of copper, too, are punched with small holes about the hundredth of an inch in diameter, in such multitudes that more of the sheet of metal is removed than remains behind; and plates of tin have been perforated with above three thousand holes in each square inch.

1[illegible]. The inlaid plates of brass and rosewood, called *buhl work*, which ornament our furniture, are formed by punching; but in this instance, both the parts cut out and those which remain are in many cases employed. In the remaining illustrations of the art of copying by punching, the part used is that which is punched out.

106. *Cards for Guns.*—The substitution of a circular disk of thin card instead of paper, for retaining in its place the charge of a fowling-piece, is attended with considerable advantage. It would, however, be of little avail, unless an easy method was contrived of producing an unlimited number of cards, each exactly fitting the bore of the barrel. The small steel tool used for this purpose cuts out innumerable circles similar to its cutting end, each of which precisely fills the barrel for which it was designed.

107. *Ornaments of Gilt Paper.*—The golden stars, leaves, and other devices, sold in shops for the purpose of ornamenting articles made of paper and paste-board, and other fancy works, are cut by punches of various forms, out of sheets of gilt paper.

108. *Steel Chains.*—The chain used in connecting the main-spring and fusee in watches and clocks is composed of small pieces of sheet steel. It is of great importance that each of these pieces should be of exactly the same size. The links are of two sorts; one of them consisting of a single oblong piece of steel with two holes in it, and the other formed by connecting two of the same pieces of steel, placed parallel to each other, at a short distance, by two rivets. These two kinds of links occur alternately; and the single piece, which forms one of them, has each end placed between the ends of the adjacent double pieces, with which it is connected by the rivets passing through all three. If the double pieces had the holes for the rivets placed at unequal distances, the chain would not be straight, and would, consequently, be unfit for its purpose.

COPYING WITH ELONGATION.

109. In this species of copying there exists but little resemblance between the copy and the original. It is the cross section of the thing produced, which is similar to the tool through which it passes. When the substances to be operated upon are hard, they frequently pass in succession thro' several holes, and it is in some cases necessary to anneal them at intervals.

110. *Wire drawing.*—The metal to be converted into wire is made of a cylindrical form, and drawn forcibly through circular holes in plates of steel: at each passage it becomes smaller; and when finished, its section at any point is a precise copy of the last hole through which it passed. Upon the larger kinds of wire, fine lines may frequently be traced, running longitudinally; these arise from a slight imperfection in the holes of the draw-plates. For many purposes of the arts, wire, the section of which is square or half round, is required; t[illegible] same method of making it is pur-

sued, except that the holes through which it is drawn are in such cases themselves square, or half round, or of whatever other form the wire is required to be. A species of wire is made, the section of which resembles a star with from six to twelve rays; this is called pinion wire, and is used by the clock-makers. They file away all the rays from a short piece, except from about half an inch near one end: this becomes a pinion for a clock; and the leaves or teeth, having passed through the *draw-plate*, are already burnished and finished.

111. *Tube drawing.*—The art of forming tubes of uniform diameter is nearly similar in its mode of execution to wire drawing. After the sheet-brass has been bent round and soldered so as to form a hollow cylinder, if the outside diameter is that which is required to be uniform, it is drawn through a succession of holes as in wire drawing. If the inside diameter is to be uniform, a succession of steel cylinders, called *triblets*, are drawn through the brass tube. In making tubes for telescopes, it is necessary that both the inside and outside should be uniform. A steel *triblet* is passed into the tube, which is then drawn through a succession of holes, until the outside diameter is reduced to the required size. The metal of which the tube is formed is condensed between the holes, and the steel cylinder within it; and when the latter is withdrawn the internal surface appears polished. The brass tube is considerably extended by this process, sometimes even to double its first length.

112. Leaden pipes for the conveyance of water were formerly made by casting; but it has been found that they can be made both cheaper and better by drawing them through holes in the manner of wire. A cylinder of lead, of five or six inches in diameter, and about two feet long, is cast with a small hole through its axis, and an iron *triblet* of fifteen feet in length is forced into the hole. It is then drawn through a series of holes, until the lead has extended from one end to the other of the *triblet*, and is of the proper thickness in proportion to the size of the pipe.

113. *Iron rolling.*—When cylinders of iron of greater thickness than wire are required, they are formed by passing wrought iron between rollers, each of which has sunk in it a semi-cylindrical groove; and as such rollers rarely touch accurately, a longitudinal line will usually be observed in iron so manufactured. Bar iron is thus shaped into all the various forms of round, square, half-round, oval, &c., in which it occurs in commerce. A particular species of moulding is thus made, which resembles in its section that part of the frame of a window which separates two adjacent panes of glass. Being much stronger than wood, it can be considerably reduced in thickness, and consequently offers less obstruction to the light: it is much used for sky-lights.

114. It is sometimes required that the iron thus produced shall not be of uniform thickness throughout. This is the case in rolling iron for railroads, for which purpose greater depth is required towards the middle of the rail, which is at the greatest distance from the supports. This is accomplished by cutting the groove in the rollers deeper at those parts where additional strength is required, so that the hollow which surrounds the roller would, if it could be unwound, be a mould of the shape the iron is intended to fit.

115. *Vermicelli.*—The various forms into which this paste is made are given by forcing it through holes in tin plate. It passes through them, and appears on the other side in long strings. The cook and the confectioner make use of the same method; the former in preparing butter and ornamental pastry for the table, the latter in forming the cylindrical lozenges of various composition.

OF COPYING WITH ALTERED DIMENSIONS.

116. *Of the Pentagraph.*—This mode of copying is chiefly used for drawings or maps: the instrument is simple; and, although usually employed in reducing, is capable of enlarging the size of the copy produced. An automaton figure, which drew profiles of its visiters, and which was exhibited in London a short time since, was regulated by a mechanism on this principle. A small aperture in the wall, opposite the seat in which the person is placed whose profile is taken, conceals a camera lucida. If an assistant moves a point, connected by a pentagraph with the hand of the automaton, over the outline of the head, a corresponding profile is traced by the figure.

117. *By turning.*—The art of turning might perhaps itself be classed amongst the arts of copying. A steel axis, called a *mandril*, having a pulley attached to the middle of it, is supported at one end either by a conical point, or by a cylindrical collar, and at the other end by another *collar*, through which it passes. The extremity which projects beyond this last *collar* is formed into a screw, by which various instruments, called *chucks*, are attached to it. These *chucks* are intended to hold the various materials to be submitted to the operation of turning, and have a great variety of forms. The *mandril* is made to revolve by a strap which passes over the pulley that is attached to it, and likewise over a larger wheel moved either by the foot, or by its connection with steam or water power. All work which is executed on a *mandril* partakes in some measure of the irregularites of that *mandril;* and the perfect circularity of section which ought to exist at every part can only be insured by an equal accuracy in the *mandril* and its *collar*.

118. *Rose Engine-turning.*—This elegant art depends in a great measure on copying. The *rosettes*, or circular plates of metal, having various indentations on the faces or edges which are placed on the mandril, oblige the cut-

ting tool to trace out the same pattern on the work, and the distance of the cutting tool from the centre being usually less than the radius of the *rosette*, causes the copy to be much diminished.

119. *Copying Dies.*—A lathe has been long known in France, and recently been used at the English mint, for copying dies. A blunt point is carried by a very slow spiral movement successively over every part of the die to be copied, and is pressed by a weight into all the cavities; while a cutting point connected with it by the machine traverses the face of a piece of soft steel, in which it cuts on the same, or on a diminished scale, the device on the original die. The degree of excellence of the copy increases in proportion as it is smaller than the original. The die of a crown-piece will furnish by copy a very tolerable die for a sixpence. But the chief use to be expected from this lathe is to prepare all the coarser parts, and leave only the finer and more expressive lines for the skill and genius of the artist.

120. An instrument not very dissimilar in principle to this was proposed for the purpose of making shoe lasts. A pattern last of a shoe for the right foot was placed in one part of the apparatus, and when the machine was moved, two pieces of wood, placed in another part which had been previously adjusted by screws, were cut into lasts greater or less than the original, as was desired; and although the pattern was for the right foot, one of the lasts was for the left, an effect which was produced by merely interposing between the two pieces to be cut into lasts a wheel which reversed the motion.

121. *Engine for copying Busts.*—Many years since, the late Mr. Watt amused himself with constructing an engine to produce copies of busts or statues, either of the same size as the original, or in a diminished proportion. The substances on which he operated were various, and some of the results were shown to his friends, but the mechanism by which they were made has never been described. More recently, Mr. Hawkins, who had also contrived several years ago a similar machine, has placed it in the hands of an artist, who has made copies in ivory of a variety of busts. The art of multiplying in *different sizes* the figures of the sculptor, aided by that of rendering their acquisition cheap through the art of casting, promises to give additional value to his productions, and to diffuse more widely the pleasure arising from their possession.

122. *Screw-cutting.*—When this operation is performed in the lathe by means of a screw upon the *mandril*, it is essentially an art of copying, but it is only the number of threads in a given length which is copied; the *form* of the thread and length, as well as the diameter of the screw to be cut, are entirely independent of those from which the copy is made. There is another method of cutting screws in a lathe by means of one pattern screw, which, being connected by wheels with the *mandril*, guides the cutting point. In this process, unless the time of revolution of the *mandril* is the same as that of the screw which guides the cutting point, the number of threads in a given length will be different. If the *mandril* move quicker than the cutting-point, the screw which is produced will be finer than the original; if it move slower, the copy will be more coarse than the original. The screw thus generated may be finer or coarser—it may be larger or smaller in diameter—it may have the same or a greater number of threads than that from which it is copied; yet all the defects which exist in the original will be accurately transmitted under the modified circumstances to every individual generated from it.

123. *Printing from Copper-Plates with altered Dimensions.*—Some very singular specimens of an art of copying, not yet made public, were brought from Paris a few years since. A watch-maker in that city, of the name of Gonord, had contrived a method by which he could take from the same copper-plate impressions of different sizes, either larger or smaller than the original design. Having procured four impressions of a parrot, surrounded by a circle, executed in this manner, I showed them to the late Mr. Lowry, an artist equally distinguished by his skill, and for the many mechanical contrivances with which he enriched his art. The relative dimensions of the several impressions were 5·5, 6·3, 8·4, 15·0, so that the largest was nearly three times the linear size of the smallest; and Mr. Lowry assured me, that he was unable to detect any lines in one which had not corresponding lines in the others. There appeared to be a difference in the quantity of ink, but none in the traces of the engraving; and, from the general appearance, it was conjectured that the largest but one was the original impression from the copper-plate. The processes by which this singular operation was executed have not been published; but two conjectures were formed at the time which merit notice. It was supposed that the artist was in possession of some method of transferring the ink from the lines of the copper-plate to the surface of some fluid, and of re-transferring the impression from the fluid to paper. If this could be accomplished, the print would be exactly the same size as the copper from which it was derived; but if the fluid were contained in a vessel having the form of an inverted cone, with a small aperture at the bottom, the liquid might be lowered or raised in the vessel by gradual abstraction or addition through the apex of the cone; in this case, the surface to which the printing-ink adhered would diminish or enlarge, and in this altered state the impression might be re-transferred to paper. It must be admitted, that this conjectural explanation is liable to very considerable difficulties; for although the converse operation of taking an impression from a liquid surface has a parallel in the art of marbling paper, the possibility of transferring the ink from the copper to the fluid requires to be proved. Another and more

plausible explanation is founded on the elastic nature of the compound of glue and treacle, a substance already in use in transferring engravings to earthenware. It is conjectured, that an impression from the copper-plate is taken upon a large sheet of this composition; that this sheet is then stretched in both directions, and that the ink thus expanded is transferred to paper. If the copy is required to be smaller than the original, the elastic substance must first be stretched, and then receive the impression from the copper-plate: on removing the tension it will contract, and thus reduce the size of the design. It is possible that one transfer may not in all cases suffice; as the extensibility of the composition of glue and treacle, although considerable, is still limited. Perhaps sheets of India rubber of uniform texture and thickness may be found to answer better than this composition; or possibly the ink might be transferred from the copper-plate to the surface of a bottle of this gum, which bottle might, after being expanded by forcing air into it, give up the enlarged impression to paper. As it would require considerable time to produce impressions in this manner, and there might arise some difficulty in making them all of precisely the same size, the process might be rendered more certain and expeditious by performing that part of the operation which depends on the enlargement or diminution of the design only once; and, instead of printing from the soft substance, transferring the design from it to stone: thus a considerable portion of the work would be reduced to an art already well known, that of lithography. This idea receives some confirmation from the fact, that in another set of specimens, consisting of a map of St. Petersburg, of several sizes, a very short line, evidently an accidental defect, occurs in all the impressions of one particular size, but not in any of a different size.

124. *Machine to produce Engravings from Medals.*—An instrument was contrived a long time ago, and is described in the *Manuel de Tourneur*, by which copper-plate engravings are produced from medals and other objects in relief. The medal and the copper are fixed on two sliding plates at right angles to each other, so connected that when the plate on which the medal is fixed is raised vertically by a screw, the slide holding the copper-plate is advanced by an equal quantity in the horizontal direction. The medal is fixed on the vertical slide with its face opposite the copper-plate, and a little above it.

A bar, terminating at one end in a tracing-point, and at the other by a short arm, at right angles to the bar, and holding a diamond-point, is placed horizontally above the copper, so that the tracing-point shall touch the medal to which the bar is perpendicular, and the diamond-point shall touch the copper-plate to which the arm is perpendicular.

Under this arrangement, if the bar is moved always parallel to itself, and consequently to the copper, while the tracing-point is kept in contact with the medal, then if the tracing-point pass over a flat part of the medal, the diamond-point will draw a straight line of equal length upon the copper; but, if the tracing-point pass over any projecting part of the medal, the deviation from the straight line by the diamond-point will be exactly equal to the elevation of the corresponding point of the medal above the rest of the surface. Thus, by the transit of this tracing-point over any segment of the medal, the diamond will draw upon the copper a section of the medal through that plane.

A screw is attached to the apparatus, so that if the medal be raised a very small quantity by the screw, the copper-plate will be advanced by the same quantity, and thus a new line of section may be drawn: and, by continuing this process, the series of sectional lines on the copper produce the representation of the medal on a plane; the outside and the form of the figure arising from the sinuosities of the lines, and from their greater or less proximity. The effect of this kind of engraving is very striking; and in some specimens gives a high degree of apparent relief. It has been practised on plate glass, and is then additionally curious from the circumstance of the fine lines traced by the diamond being invisible, except in certain lights.

From this description it will be seen that the engraving on the copper must be distorted; that is to say, that the apparent projection on the copper will not be the same as that which arises from a perpendicular projection of each point of the medal upon a plane parallel to itself. Consequently, the position of the prominent parts will be more altered than that of the less elevated; and the greater the relief of the medal the more distorted will be its engraved representation. Mr. John Bate, son of Mr. Bate, of the Poultry, has contrived an improved machine, for which he has taken a patent, in which this source of distortion is remedied.

The inconvenience which arises from too high a relief in the medal, or in the bust, might be remedied by some mechanical contrivance, by which the deviation of the diamond-point from the right line, (which it would describe when the tracing-point traverses a plane,) is made proportional—not to the elevation of the corresponding point above the plane of the medal, but above some other parallel plane removed to a fit distance behind it. Thus busts and statues might be reduced to any required degree of relief.

125. The machine just described naturally suggests other views which seem to deserve consideration, and, perhaps, some experiment. If a medal were placed under the tracing-point of a pentagraph, an engraving tool substituted for the pencil, and a copper-plate in the place of the paper; and if, by some mechanism, the tracing-point, which slides in a vertical plane as it is carried over the different elevations of

the medal, could increase or diminish the depth of the engraved line proportionally to the actual height of the corresponding point on the medal, then an engraving would be produced, free at least from any distortion, although it might be liable to objections of a different kind. If, by any similar contrivance, instead of lines, we could make on each point of the copper a dot, varying in size or depth with the altitude of the corresponding point of the medal above its plane, then a new species of engraving would be produced; and the variety of these might again be increased, by causing the graving point to describe a very small circle of a diameter, varying with the height of the point on the medal above a given plane, or by making the graving-tool consist of three equi-distant points, whose distance increased or diminished according to some determinate law, dependant on the elevation of the point represented above the plane of the medal. It would, perhaps, be difficult to imagine the effects of some of these kinds of engravings; but they would all possess, in common, the property of being projections, by parallel lines, on the objects represented, and the intensity of the shade of the ink would either vary according to some function of the distance of the point represented from some given plane, or it would be a little modified by the distances from the same plane of a few of the immediate contiguous points.

126. *Lace made by Caterpillars.*—A most extraordinary species of manufacture, which is in a slight degree connected with copying, has been contrived by an officer of engineers, residing at Munich. It consists of lace, and veils, with open patterns in them, made entirely by caterpillars. The following is the mode of proceeding adopted:—Having made a paste of the leaves of the plant, on which the species of caterpillar he employs feeds, he spreads it thinly over a stone, or other flat substance, of the required size. He then, with a camel-hair pencil dipped in olive oil, draws the pattern he wishes the insects to leave open. This stone is then placed in an inclined position, and a considerable number of the caterpillars are placed at the bottom. A peculiar species is chosen, which spins a strong web; and the animals commence at the bottom, eating and spinning their way up to the top, carefully avoiding every part touched by the oil, but devouring every other part of the paste. The extreme lightness of these veils, combined with some strength, is truly surprising. One of them, measuring twenty-six and a half inches by seventeen inches, weighed only 1·51 grains, a degree of lightness which will appear more strongly by contrast with other fabrics. One square yard of the substance of which these veils are made, weighs four grains and one third, whilst one square yard of silk gauze weighs one hundred and thirty-seven grains, and one square yard of the finest patent net weighs two hundred and sixty-two grains and a half. The ladies' colored muslin dresses, mentioned in the table subjoined, cost ten shillings per dress, and each weighs six ounces; the cotton from which they are made weighing nearly six and two-ninths ounces avoirdupois weight.

Weight of one square yard of each of the following articles*:

Description of Goods.	Value per yard meas. s.	d.	Weight finished of one sq. yd. Troy grs.	Weight of cott'n used in making one sq. yd. Troy grs.
Caterpillar Veils,	-	-	$4\frac{1}{3}$	-
Silk Gauze $\frac{3}{4}$ wide,	1	0	137	-
Finest Patent Net,	-	-	$262\frac{1}{2}$	-
Fine Cambric Muslin,	-	-	551	-
6-4ths Jaconet Muslin,	2	0	613	670
Ladies' colored Muslin Dresses,	3	0	788	875
6-4ths Cambric,	1	2	972	1069
9-8ths Calico,	0	9	988	1085
1-2 yard Nankeen,	0	8	2340	2432

127. This enumeration, which is far from complete, of the arts in which copying is the foundation, may be terminated with an example which has long been under the eye of the reader; although few, perhaps, are aware of the number of repeated copyings of which these pages are the subject.

1. They are copies, by printing, from stereotype plates.

2. These stereotype plates are copied by casting the plaster in a liquid state upon the moveable types set up by the compositor.

[It is here that the union of the intellectual and the mechanical department takes place. The mysteries, however, of an author's copying form no part of our inquiry, although it may be fairly remarked that, in numerous instances, the mental far eclipses the mechanical copyist.]

4. These moveable types, the obedient messengers of the most opposite thoughts, the most conflicting theories, are themselves copies by casting from moulds of copper called *matrices*.

5. The lower part of these *matrices*, bearing the impressions of the letter or character intended, are copies, by punching, from steel punches on which the same character exists in relief.

6. These steel punches are not themselves entirely exempted from the great principle of art. Many of the cavities which exist in them, such as those in the middle of the punches for the letters *a*, *b*, *d*, *e*, *g*, &c., are produced from other steel punches, in which these parts are in relief.

We have thus traced through six successive stages of copying the mechanical art of printing from stereotype plates; the principle of copying contributing in this, as in every other department of manufacture, to the uniformity and the cheapness of the work produced.

* Some of these weights and measures are calculated from a statement in the Report of the Committee of the House of Commons on Printed Cotton Goods, and the widths of the pieces there given are presumed to be the real widths, not those by which they are called in the retail shops.

ON THE METHOD OF OBSERVING MANUFACTORIES.

128. Having now reviewed the *mechanical* principles which regulate the successful application of mechanical science to great establishments for the production of manufactured goods, it remains for us to suggest a few inquiries, and to offer a few observations to those whom an enlightened curiosity may lead to examine the factories of this or of other countries.

The remark—that it is important to commit to writing all information as soon as possible after it is received, especially when numbers are concerned—applies to almost all inquiries. It is frequently impossible to do this at the time of visiting an establishment, although not the slightest jealousy may exist; the mere act of writing information as it is communicated orally, is a great interruption to the examination of machinery. In such cases, therefore, it is advisable to have prepared beforehand the questions to be asked, and to leave blanks for the answers, which may be quickly inserted, as, in a multitude of cases, they are merely numbers. Those who have not tried this plan will be surprised at the quantity of information which may, through its means, be acquired, even by a short examination. Each manufacture requires its own list of questions, which will be better drawn up after the first visit. The following outline, which is very generally applicable, may suffice for an illustration; and, to save time, it may be convenient to have it printed, and to bind up, in the form of a pocket-book, a hundred copies of the skeleton forms for processes, with about twenty of the general inquiries.

General Inquiries.—Outlines of a Description of any of the Mechanical Arts ought to contain Information on the following points:

Brief sketch of its history, particularly the date of its invention and its introduction into England.

Short reference to the previous state through which the material employed has passed; the places whence it is procured; the price of a given quantity.

The various processes must now be described successively, according to the plan which will be given in Sec. 129; after which the following information should be given:

Are various kinds of the same article made in one establishment or at different ones, and are there differences in the processes?

To what defects are the goods liable?

What substitutes or adulterations are used?

What waste is allowed by the master?

What tests are there of the goodness of the manufactured article?

The weight of a given quantity, or number, and a comparison with that of the raw material.

The wholesale price at the manufactory £ *s.* *d.* per

The usual retail price £ *s.* *d.* per

Who provide tools? Master, or men? Who repair tools? Master, or men?

What is the expense of the machinery?

What is the annual wear and tear, and what its duration?

Is there any particular trade for making it? Where?

Is it made and repaired at the manufactory?

In any manufactory visited, state the number (   ) of processes, and of the persons employed in each process, and the quantity of manufactured produce.

What quantity is made annually in Great Britain?

Is the capital invested in manufactories large or small?

Mention the principal seats of this manufacture in England; and if it flourishes much abroad, the places where it is established.

The duty, excise, or bounty, if any, should be stated, and any alterations in past years; and also the amount exported or imported for a series of years.

Whether the same article, but of superior, equal, or inferior make, is imported?

Does the manufacturer export, or sell to a middle-man, who supplies the merchant?

To what countries is it chiefly sent—and in what goods are the returns made?

129. Each process requires a separate skeleton, and the following outline will be sufficient for many different manufactories:

Process (   ) Manufacture (   )
Place (   ) Name (   )
date   183

The mode of executing it, with sketches of the tools or machine, if necessary.

The number of persons necessary to attend the machine.

Are the operatives men, (   ) women, (   ) or children (   )? If mixed, what are the proportions?

What is the pay of each? (*s.* *d.*) (*s.* *d.*) (*s.* *d.*) per

What number (   ) of hours do they work per day?

Is it usual, or necessary, to work night and day without stopping?

Is the labor performed by piece or by day-work?

Who provide tools? Master, or men? Who repair tools? Master, or men?

What degree of skill is required, and how many years (   ) apprenticeship?

The number of times (   ) the operation is repeated per day or per hour.

The number of failures (   ) in a thousand.

Whether the workman or the master loses by the broken or damaged articles?

What is done with them?

If the same process is repeated several times, state the diminution or increase of measure, and the loss, if any, at each repetition.

130. In using this skeleton, the answers to the questions are in some cases printed, as—

Who repair tools? Masters, Men: in order that the proper answer may be underlined with a pencil. In filling up the answers which require numbers, some care should be taken; for instance, if the observer stands with his watch in his hand before a person heading a pin, the workman will almost certainly increase his speed, and the estimate will be too large. A much better average will result from inquiring what quantity is considered a fair day's work. When this cannot be ascertained, the number of operations performed in a given time may frequently be ascertained when the workman is quite unconscious that any person is observing him. Thus, the sound made by the motion of a loom may enable the observer to count the number of strokes per minute, even though he is outside the building in which it is contained. M. Coulomb, who had great experience in making such observations, cautions those who may repeat his experiments against being deceived by such circumstances: "Je prie (says he) ceux qui voudront les repeter, s'ils n'ont pas le temps de mesurer les resultats apres plusieurs jours d'un travail continu, d'observer les ouvriers à differentes reprises dans la journee, sans qu'ils sachent qu'ils sont observes. L'on ne peut trop avertir combien l'on risque de se tromper en calculant, soit la vitesse, soit le temps effectif du travail, d'apres une observation des quelques minutes." (*Memoires de l'Institut. Tom. II. p.* 247.)—It frequently happens, that, in a series of answers to such questions, there are some which, although given directly, may also be deduced by a short calculation from others that are given or known; and advantage should always be taken of these verifications, in order to confirm the accuracy of the statements; or, in case they are discordant, to correct the apparent anomalies. In putting lists of questions into the hands of persons undertaking to give information upon any subject, it is in some cases desirable to have an estimate of the soundness of his judgment. The questions can frequently be so shaped that some of them may indirectly depend on others; and one or two may be inserted whose answers can be obtained by other methods; nor is this process without its advantages in enabling us to determine the value of our own judgment. The habit of forming an estimate of the magnitude or frequency of any object immediately previous to our applying to it measure or number, tends materially to fix our attention and to improve our judgment.

DISTINCTION BETWEEN MAKING AND MANUFACTURING.

131. The *economical principles* which regulate the application of machinery, and which govern the interior of all our great factories, are quite as essential to the prosperity of a great commercial country as are those mechanical principles, the operations of which have been illustrated in the preceding section.

The first object of every person who attempts to make any article of consumption, is, or ought to be, to produce it in a perfect form; but in order to secure to himself the greatest and most permanent profit, he must endeavor by every means in his power to render the new luxury or want, which he has created, cheap to those who consume it. The larger number of purchasers thus obtained will, in some measure, secure him from the caprices of fashion, whilst it furnishes a far greater amount of profit, although the contribution of each individual is diminished. The importance of collecting data for the purpose of enabling the manufacturer to ascertain how many additional customers he will acquire by a given reduction in the price of the article he makes, cannot be too strongly pressed upon the attention of those who employ themselves in statistical inquiries. In some ranks of society, any diminution of price in a commodity will bring forward but few additional customers; whilst, in other classes, a very small reduction will so enlarge the sale as to yield a considerable increase of profit.

132. If, therefore, the *maker* of an article wish to become a *manufacturer* in the more extended sense of the term, he must attend to other principles besides those mechanical ones on which the successful execution of his work depends; and he must carefully arrange the whole system of his factory in such a manner, that the article he sells to the public may be produced at as small a cost as possible. Should he not be actuated at first by motives so remote, he will, in every highly civilized country, be compelled, by the powerful stimulus of competition, to attend to the principles of the domestic economy of manufactures. At every reduction in price of the commodity he makes, he will be driven to seek compensation in a saving of expense in some of the processes; and his ingenuity will be sharpened in this inquiry by the hope of being able in his turn to undersell his rivals. The benefit of the improvements thus engendered is, for a short time, confined to those from whose ingenuity they derived their origin; but when a sufficient experience has proved their value, they become generally adopted, until in their turn they are superseded by other more economical methods.

133. There exists a considerable difference between the terms *making* and *manufacturing*. The former refers to the production of *a small*, the latter to that of *a very large number of individuals*; and the difference is well illustrated in the evidence given before the Committee of the House of Commons on the Export of Tools and Machinery. On that occasion Mr. Maudslay stated, that he had been applied to by the Navy Board to make iron tanks for ships, and that he was rather unwilling to do so, as he considered it to be out of his line of business; however, he undertook to make one as a trial. The holes for the rivets were punched by hand-punching with presses, and the 1680 holes

which each tank required, cost seven shillings. The Navy Board, who required a large number, proposed that he should supply forty tanks a week for many months. The magnitude of the order made it worth while to commence *manufacturer*, and to make tools for the express business. Mr. Maudslay, therefore, offered, if the Board would give him an order for two thousand tanks, to supply them at the rate of eighty per week. The order was given: he made tools, by which the expense of punching the rivet-holes of each tank was reduced from seven shillings to nine-pence; he supplied ninety-eight tanks a week for six months, and the price charged for each was reduced from seventeen pounds to fifteen.

ON THE INFLUENCE OF VERIFICATION ON PRICE.

134. The money price of an article at any given period is usually stated to depend upon the proportion between the supply and the demand. The average price of the same article during a long period is said to depend, ultimately, on the power of producing and selling it with the ordinary profits of capital. But these principles, although true in their general sense, are yet so often modified by the influence of others, that it becomes necessary to examine a little into the disturbing forces.

135. With respect to the first of these propositions, it may be observed that the cost of any article to the purchaser includes, besides supply and demand, another element, which, though often of little importance, is in many cases of great consequence. The cost, to the purchaser, is the price he pays for any article, added to the cost of verifying the fact of its having that degree of goodness for which he contracts. In some cases the goodness of the article is evident on mere inspection; and in these cases there is not much difference of price at different shops. The goodness of loaf-sugar, for instance, can be discerned almost at a glance; and the consequence is, that the price of it is so uniform, and the profit upon it so small, that no grocer is at all anxious to sell it: whilst, on the other hand, tea, of which it is exceedingly difficult to judge, and which can be adulterated by mixture so as to deceive the skill even of a practiced eye, has a great variety of different prices, and is that article which every grocer is most anxious to sell to his customers. The difficulty and expense of verification are, in some instances, so considerable, as to justify the deviation from well established principles. Thus, it has been found so difficult to detect the adulteration of flour, and to measure its good qualities, that, contrary to the maxim that *government* can generally purchase any article at a cheaper rate than that at which they can manufacture it, it has been considered more economical to build extensive flour-mills, (such as those at Deptford,) and to grind their own corn, than to verify each sack purchased, and to employ persons in continually devising methods of detecting the new modes of adulteration which might be resorted to.

136. Some years since, a mode of preparing old clover and trefoil seeds by a process called "*doctoring*" became so prevalent as to excite the attention of the House of Commons. It appeared in evidence before a committee, that the old seed of the white clover was *doctored* by first wetting it slightly, and then drying it with the fumes of burning sulphur; and that the red clover seed had its color improved by shaking it in a sack with a small quantity of indigo; but this being detected after a time, the *doctors* then used a preparation of logwood, fined by a little copperas, and sometimes by verdigris; thus at once improving the appearance of the old seed, and diminishing, if not destroying, its vegetative power already enfeebled by age. Supposing no injury had resulted to good seed so prepared, it was proved that, from the improved appearance, its market price would be enhanced by this process from five to twenty-five shillings a hundred weight. But the greatest evil arose from the circumstance of these processes rendering old and worthless seed, in appearance, equal to the best. One witness tried some *doctored* seed, and found that not above one grain in a hundred grew, and that those which did vegetate died away afterwards; whilst about eighty or ninety per cent. of good seed usually grows. The seed so treated was sold to retail dealers in the country, who, of course, endeavored to purchase at the cheapest rate, and from them it got into the hands of the farmers; neither of these classes being at all capable of distinguishing the fraudulent from the genuine seed. Many cultivators, in consequence, diminished their consumption of the article; and others were obliged to pay a higher price to those who had skill to distinguish the mixed seed, and who had integrity and character to prevent them from dealing in it.

137. In the Irish flax trade, a similar example of the high price paid for verification occurs. It is stated in the report of the committee—"That the natural excellent quality of Irish flax, as contrasted with foreign or British, has been admitted." Yet from the evidence before that committee, it appears that Irish flax sells, in the market, from 1*d.* to 2*d.* per pound less than other flax of equal or inferior quality. Part of this difference of price arises from negligence in its preparation, but a part also from the expense of ascertaining that each parcel is free from stones and rubbish to add to its weight: this appears from the evidence of Mr. J. Corry, who was, during twenty-seven years, Secretary to the Irish Linen Board:

"The owners of the flax, who are almost always people in the lower classes of life, believe that they can best advance their own interests by imposing on the buyers. Flax being sold by weight, various expedients are used to increase it; and every expedient is injurious, particularly the damping of it,—a very common prac-

tice, which makes the flax afterwards heat. The inside of every bundle (and the bundles all vary in bulk) is often full of pebbles, or dirt of various kinds, to increase the weight. In this state it is purchased, and exported to Great Britain. The natural quality of Irish flax is admitted to be not inferior to that produced by any foreign country; and yet the flax of every foreign country, imported into Great Britain, obtains a preference among the purchasers, because the foreign flax is brought to the British market in a cleaner and more regular state. The extent and value of the sales of foreign flax in Great Britain can be seen by reference to the public accounts; and I am induced to believe, that Ireland, by an adequate extension of her flax tillage, and having her flax markets brought under good regulations, could, without encroaching in the least degree upon the quantity necessary for her home consumption, supply the whole of the demand of the British market, to the exclusion of the foreigners."

138. The lace trade affords other examples; and, in inquiring into the complaints made to the House of Commons by the frame-work knitters, the committee observe, that "It is singular that the grievance most complained of one hundred and fifty years ago, should, in the present improved state of the trade, be the same grievance which is now most complained of; for it appears, by the evidence given before your committee, that all the witnesses attribute the decay of the trade more to the making of fraudulent and bad articles, than to the war, or to any other cause." And it is shown by the evidence, that a kind of lace called "*single-press*" was manufactured, which was only looped once, and which, although good to the eye, became nearly spoiled in washing by the slipping of the threads; that not one person in a thousand could distinguish the difference between "*single-press*" and "*double-press lace*;" and that, even workmen and manufacturers were obliged to employ a magnifying glass for that purpose; and that, in another similar article, called "*warp lace*," such aid was essential. It was also stated by one witness, that

"The trade had not yet ceased, excepting in those places where the fraud had been discovered; and from those places no orders are now sent for any sort of Nottingham lace, the credit being totally ruined."

139. In the stocking trade similar frauds have been practised. It appeared in evidence, that stockings were made of uniform width from the knee down to the ankle, and being wetted and stretched on frames at the calf, they retained their shape when dry; but that the purchaser could not discover the fraud, until, after the first washing, the stocking appeared to hang like a bag about his ankles.

140. In the watch trade, the practice of deceit, in forging the marks and names of respectable makers, has been carried to a great extent both by natives and foreigners; and the effect upon our export trade has been most injurious, as the following extract from the evidence before a committee of the House of Commons will prove:

"*Question.*—How long have you been in the trade?

"*Answer.*—Nearly thirty years.

"*Question.*—The trade is at present much depressed?

"*Answer.*—Yes, sadly.

"*Question.*—What is your opinion of the cause of that distress?

"*Answer.*—I think it is owing to a number of watches that have been made so exceedingly bad that they will hardly look at them in the foreign markets; all with a handsome outside show, and the works hardly fit for any thing.

"*Question.*—Do you mean to say, that all the watches made in this country are of that description?

"*Answer.*—No; only a number which are made up by some of the Jews, and other low manufacturers. I recollect something of the sort years ago, of a fall-off of the East India work, owing to there being a number of handsome looking watches sent out, for instance, with hands on and figures, as if they showed seconds, and had not any regular work to show the seconds: the hand went round, but it was not regular.

"*Question.*—They had no perfect movements?

"*Answer.*—No, they had not; that was a long time since, and we had not any East India work for a long time afterwards."

In the home market, inferior but showy watches are made at a cheap rate, which are not warranted by the maker to go above half an hour: about the time occupied by the Jew pedlar in deluding his country customer.

141. The practice, in retail linen-drapers' shops, of calling certain articles yard-wide when the real width is, perhaps, only seven-eighths or three-quarters, arose at first from fraud, which being detected, custom was pleaded in its defence; but the result is, that the vender is constantly obliged to measure the width of his goods in the customer's presence. In all these instances, the object of the seller is to get a higher price than his goods would really produce if their quality were known; and the purchaser, if not himself a skilful judge (which rarely happens to be the case), must pay some person, in the shape of an additional money price, who has skill to distinguish, and integrity to furnish, articles of the quality agreed on. But as the confidence of persons in their own judgment is usually great, large numbers will always flock to the cheap dealer, who thus, attracting many customers from the honest tradesman, obliges him to charge a higher price for his judgment and character, than, without such competition, he could afford to do.

142. There are few articles which the public are less able to judge of than the quality of

drugs; and when they are compounded into medicines, it is scarcely possible, even for medical men, to decide whether pure or adulterated drugs have been employed. This circumstance, concurring with an injudicious mode adopted in the payment for medical assistance, has produced a curious effect on the price of medicines. Apothecaries, instead of being paid for their services and skill, have been remunerated by being allowed to place a high charge upon the medicines they administer, which are confessedly of very small pecuniary value. The tendency of such a system is to offer an inducement to prescribe more medicine than is necessary; and, in fact, even with the present charges, the apothecary, in ninety-nine cases out of a hundred, cannot be fairly remunerated unless the patient either takes, or pays for, more physic than is really necessary. The apparent extravagance of the charge of eighteen pence for a two-ounce phial* of medicine is obvious to many who do not reflect on the circumstance that the charge is, in reality, for the payment of professional skill. As the same charge is made by the apothecary, whether he attends the patient or merely prepares the prescription of a physician, the chemist and druggist soon offered to furnish the same commodity at a greatly diminished price. But the eighteen pence charged by the apothecary might have been fairly divided into two parts, three pence for medicine and bottle, and fifteen pence for attendance. Now the chemist, although he has reduced the price of the apothecary's draught, from thirty-three to forty-four per cent., yet realizes a profit of between two and three hundred per cent. on the ten pence or shilling he charges for the same compound. This enormous profit has called into existence a multitude of competitors; and in this instance the impossibility of verifying has, in a great measure, counteracted the beneficial effects of competition. The general adulteration of drugs, even at the extremely high price at which they are retailed as medicine, enables those who are imagined to sell them in an unadulterated state to make large profits, whilst the same evil frequently disappoints the expectation and defeats the skill of the most eminent physician.

It is difficult to point out a remedy for this evil without suggesting an almost total change in the system of medical practice. If the apothecary were to charge for his visits, and to reduce his medicines to one-fourth or one-fifth of their present price, he would still have an interest in procuring the best drugs, for the sake of his own reputation or skill. Or if the medical attendant, who is paid more highly for his time, were to have several pupils, he might himself supply the medicines without a specific charge, and his pupils would derive improvement from compounding them, as well as from examining the purity of the drugs he would purchase. The public would derive several advantages from this arrangement. In the first place, it would be greatly for the interest of the medical practitioner to have the best drugs; it would also be his interest not to give more physic than needful; and it would also enable him, through some of his more advanced pupils, to watch more frequently the changes of any malady.

143. The principle that *price*, at any moment, is dependent on the relation of the supply to the demand, is true to the full extent only when the whole supply is in the hands of a very large number of small holders, and the demand is caused by the wants of another set of persons, each of whom requires only the same very small quantity. And the reason appears to be, that it is only in such circumstances that a uniform average can be struck between the feelings, the passions, the prejudices, the opinions, and the knowledge, of both parties. If the supply, or present stock in hand, be entirely in the possession of one person, he will naturally endeavor to put such a price upon it as shall produce by its sale the greatest quantity of money; but he will be guided in this estimate of the price at which he will sell both by the knowledge that increased price will cause a diminished consumption, and by the desire to realize his profit before a new supply shall reach the market from some other quarter. If, however, the same stock is in the hands of several dealers, there will be an immediate competition between them, arising partly from their different views of the duration of the present state of supply, and partly from their own peculiar circumstances with respect to the employment of their capital.

144. Again, if the commodity itself is of a perishable nature, such, for example, as a cargo of ice imported into the port of London from Norway a few summers since, then time will supply the place of competition; and, whether the article is in the possession of one or of many persons, it will scarcely reach a monopoly price. The history of *cajeput oil*, during the last few months, offers a curious illustration of the effect of opinion upon price. In July of last year (1831) cajeput oil was sold, exclusive of duty, at 7*d.* per ounce. The disease which had ravaged the east was then supposed to be approaching our shores, and its proximity created alarm. At this period, the oil in question began to be much talked of as a powerful remedy in that dreadful disorder; and in September it rose to the price of 3*s.* and 4*s.* the ounce. In October there were few or no sales: but in the early part of November, the speculations in this substance reached their height, and between the 1st and the 15th it realized the following prices: 3*s.* 9*d.*, 5*s.*, 6*s.* 6*d.*, 7*s.* 6*d.*, 8*s.* 9*d.*, 10*s.*, 10*s.* 6*d.*, 11*s.* After the 15th of November, the holders of cajeput oil were anxious to sell at much

* Apothecaries frequently purchase these phials at the old bottle-warehouses at ten shillings per gross, so that when their servant has washed them the cost of the phial is nearly one penny.

lower rates; and in December a fresh arrival was offered by public sale at 5*s*., and withdrawn, being sold afterwards, as it was understood, by private contract, at 4*s*. or 4*s*. 6*d*. per ounce. Since that time, 1*s*. 6*d*. and 1*s*. have been realized: and a fresh arrival, which is daily expected, (March, 1832,) will probably reduce it below the price of July. Now, it is important to notice that, in November, the time of greatest speculation, the quantity in the market was held by *few* persons, and that it frequently changed hands, each holder being desirous to realize his profit. The quantity imported since that time has also been considerable.*

145. The frequent speculations in oil, tallow, and other commodities, which must occur to the memory of most of my readers, were always founded on the principle of purchasing up all the stock on hand, and agreeing for the purchase of the expected arrivals; thus proving the opinion of capitalists to be, that a larger average price may be procured by the stock being held by few persons.

ON THE INFLUENCE OF DURABILITY ON PRICE.

146. Having now considered the circumstances that modify what may be called the momentary amount of price, we must next examine a principle which seems to have an effect on its permanent average. The durability of any commodity influences its cost in a permanent manner. We have already stated, that what may be called the *momentary price* of any commodity depends upon the proportion existing between the supply and demand, and also upon the cost of verification. The *average price*, during a long period, will depend upon the labor required for producing and bringing it to market, as well as upon the average supply and demand; but it will also be influenced by the *durability of the article manufactured.*

Many *things* in common use are substantially consumed in using: a phosphorus match, articles of food, and a cigar, are examples of this description. Some things after use become inapplicable to their former purposes, as paper which has been printed upon; but it is yet available for the cheesemonger or the trunkmaker. Some articles, as pens, are quickly worn out by use; and some are still valuable after a long-continued wear. There are others, few, perhaps, in number, which never wear out; the harder precious stones, when well cut and polished, are of this latter class; the fashion of the gold or silver mounting in which they are set may vary with the taste of the age, and such ornaments are constantly exposed for sale as second-hand, but the gems themselves, when removed from their supports, are never so considered. A brilliant, which has successively graced the necks of a hundred beauties, or glittered for a century upon patrician brows, is weighed by the diamond merchant in the same scale with another which has just escaped from the wheel of the lapidary, and will be purchased or sold by him at the same price per carat. The great mass of commodities is intermediate in its character between these two extremes, and the periods of respective duration are very various. It is evident that the average price of those things which are consumed in the act of using them, can never be less than that of the labor of bringing them to market. They may, for a short time, be sold for less; but under such circumstances their production must soon cease altogether. On the other hand, if an article never wears out, the consequence will be, that its price may continue *permanently below* the cost of the labor expended in producing it; and the only consequence will be, that no farther production will take place: its price will continue to be regulated by the relation of the supply to the demand; and should that at any after time rise, for a considerable period, above the cost of production, it will be again produced.

147. Articles become old from actual decay, or the wearing out of their parts; from improved modes of constructing them; or from changes in their form and fashion, required by the varying taste of the age. In the two latter cases, their utility is but little diminished; and, being less sought after by the classes who have hitherto employed them, they are sold at a reduced price to a class of society rather below that of their former possessors. Many articles of furniture, such as well-made tables and chairs, are thus found in the rooms of those who would have been quite unable to have purchased them when new; and we find constantly, even in the houses of the more opulent, large looking-glasses which have passed successively through the hands of several possessors, changing only the fashion of their frames; and in some instances even this alteration is omitted, an additional coat of gilding saving them from the character of being second-hand. Thus a taste for luxuries is propagated downwards in society; and, after a short period, the numbers who have acquired new wants become sufficient to excite the ingenuity of the manufacturer to reduce the cost of supplying them, whilst he is himself benefitted by the extended scale of demand.

There is a peculiarity in looking glasses with reference to the principle just mentioned. The most frequent occasion of injury to them arises from accidental violence; and the peculiarity is, that, unlike most other articles, when broken they are still of some value. If a large mirror is accidentally cracked, it is immediately cut into two or more smaller ones, each of which may be perfect. If the degree of violence is so great as to break it into many fragments, these smaller pieces may be cut into squares for dressing-glasses; and if the silvering is injured, it can either be re-silvered or used as plate-glass for glazing windows. The addition from our

* I have understood that the price of camphor, at the same time, suffered similar changes.

manufactories to the stock of plate-glass in the country is annually about two hundred and fifty thousand square feet. It would be very difficult to estimate the quantity annually destroyed or exported, but it is probably small; and the effect of these continual additions is seen in the diminished price and increased consumption of the article. Almost all the better order of shop fronts are now glazed with it. If it were quite indestructible, the price would continually diminish; and unless an increased demand arose from new uses, or from a greater number of customers, a single manufactory, unchecked by competition, would ultimately be compelled to shut up, driven out of the market by the permanence of its own productions.

OF PRICE AS MEASURED BY MONEY.

148. The *money price* at which an article sells furnishes us with comparatively little information, if we compare distant intervals of time and different countries; for gold and silver, in which price is usually measured, are themselves subject to variations, like all other commodities; nor is there any invariable standard by which such comparisons can be made. The average price of a certain quality of various manufactured or raw produce has been suggested as a permanent standard of price; but a new difficulty then presents itself: for the improved methods of producing such articles render their *money price* extremely variable within very limited periods. The annexed table will afford a striking instance of this kind of variation within a period of only twelve years.

Prices of the following articles at Birmingham in the undermentioned years.

DESCRIPTION.		1818. s.	d.	1824. s.	d.	1828. s.	d.	1830. s.	d.
Anvils - - - - - - -	per cwt.	25	0	20	0	16	0	13	0
Awls, polished, Liverpool, - -	gross	2	6	2	0	1	6	1	2
Bed Screws, 6 inches long, - -	gross	18	0	15	0	6	0	5	0
Bits, tinned, for Bridles, - -	dozen	5	0	5	0	3	3	2	6
Bolts, for doors, 6 inches, - -	dozen	6	0	5	0	2	3	1	6
Braces, for Carpenters, with 12 bits,	- set	9	0	4	0	4	2	3	5
Buttons, for Coats, - - - -	gross	4	6	6	3	3	0	2	2
Buttons, small, for Waistcoats, &c.	gross	2	6	2	0	1	2	0	8
Candlesticks, brass, 6 inches,	pair	2	11	2	0	1	7	1	2
Curry Combs, six barred, - -	dozen	2	9	2	6	1	5	0	11
Frying Pans, - - - - -	cwt.	25	0	21	0	18	0	16	0
Gun Locks, single roller, - -	each	6	0	5	2	1	10	1	6
Hammers, Shoe, No. 0, - - -	dozen	6	9	3	9	3	0	2	9
Hinges, cast butts, 1 inch, - -	dozen	0	10	0	7½	0	3¾	0	2¾
Knobs, brass, 2 inches, for Commodes,	dozen	4	0	3	6	1	6	1	2
Latches, for doors, bright thumb, -	dozen	2	3	2	2	1	0	0	9
Locks, for doors, iron rim, 6 inches,	dozen	38	0	32	0	15	0	13	6
Sad Irons, and other Castings, -	cwt.	22	6	20	0	14	0	11	6
Shovel and Tongs, fire irons, -	pair	1	0	1	0	0	9	0	6
Stirrups, plated, - - - - -	pair	4	6	3	9	1	6	1	1
Table Spoons, tinned, - - - -	gross	17	0	15	0	10	0	7	0
Trace Chains, - - - - -	cwt.	28	0	25	0	19	6	16	6
Trays, Japanned Tea, 30 inches, -	each	4	6	3	0	2	0	1	5
Vices, for Blacksmiths, &c. - -	cwt.	30	0	28	0	22	0	19	6
Wire, Iron, No. 6, - - - - -	bundle	16	0	13	0	9	0	7	0
——, Brass, - - - - - - -	- lb.	1	10	1	4	1	0	0	9

I have taken some pains to assure myself of the accuracy of the above table: at different periods of the years quoted the prices may have varied; but I believe it may be considered as a fair approximation. In the course of my inquiries I have been favored with another list, in which many of the same articles occur; but in this last instance the prices quoted are separated by an interval of twenty years. It is extracted from the books of a highly respectable house at Birmingham; and the prices confirm the accuracy of the former table, so far as they relate to the articles which are found in that list.

Prices of 1812 *and* 1832.

DESCRIPTION.		1812. s.	d.	1832. s.	d.	Reduction per cent. since 1812.
Anvils - - - - -	per cwt.	25	0	14	0	44
Awls, Liverpool blades, -	- gross	3	6	1	0	71
Candlesticks, iron, plain, - - -		3	10¾	2	3½	41
————, screwed, - - -		6	4¼	3	9	41
Bed screws, 6 inch square head,	gross	7	6	4	6	40
————, flat head, -	- gross	8	6	4	8	45
Curry Combs, 6 barred, -	- dozen	4	0¼	1	0	75
————, 8 barred, -	- dozen	5	5¼	1	5	74
————, patent, 6 barred,	- dozen	7	1½	1	5	80
————, 8 barred, -	- dozen	8	6¾	1	10	79
Fire irons, iron head, No. 1,	- dozen	1	4½	0	7¾	53
————————, No. 2,	- dozen	1	6	0	8½	53
————————, No. 3,	- dozen	1	8¼	0	9½	53
————————, No. 4,	- dozen	1	10½	0	10½	53
Gun-Locks, single roller, -	- each	7	2½	1	11	73
Locks, 1¼ brass, port. pad, -	- each	16	0	2	6	85
——, 2½ inch 3 keyed till-locks,	each	2	2	0	9	65
Shoe Tacks, - - - -	- gross	5	0	2	0	60
Spoons, tinned, iron, table, -	- gross	22	6	7	0	69
Stirrups, com. tinned, 2 bar,	- dozen	7	0	2	9	61
Trace Chains, iron, - -	- cwt.	46	9¼	15	0	68

I cannot omit availing myself of this opportunity of calling the attention of the manufacturers, merchants, and factors, in *all* our manufacturing and commercial towns, to the great importance, both for their own interests, and for that of the population to which their capital gives employment, of collecting with care such averages from the actual sales registered in their books. Nor, perhaps, would it be without its use to suggest, that such averages would be still more valuable if collected from as many different quarters as possible; and when the amount of the goods from which they are deduced, together with the greatest deviations from the mean, are given; and that if a small committee were to undertake the task, it would give great additional weight to the information. Political economists have been reproached with too small a use of facts, and too large an employment of theory. If facts are wanting, let it be remembered that the closet-philosopher is unfortunately too little acquainted with the admirable arrangements of the factory; and that no class of persons can supply so readily, and with so little sacrifice of time, the data on which all the reasonings of political economists are founded, as the merchant and manufacturer; and, unquestionably, to no class are the deduc-

tions to which they give rise so important. Nor let it be feared that erroneous deductions may be made from such recorded facts: the errors which arise from the absence of facts are far more numerous and more durable than those which result from unsound reasoning respecting true data.

149. The great diminution in price of the articles here enumerated may have arisen from several causes: 1. *The alteration in the value of the currency.* 2. *The increased value of gold in consequence of the increased demand for coin.* The first of these causes may have had some influence; and the second may have had a very small effect upon the two first quotations of prices, but none at all upon the two latter ones. 3. *The diminished rate of profit produced by capital, however employed.* This may be estimated by the average price of three per cents. at the periods stated. 4. *The diminished price of the raw materials out of which these articles were manufactured.* The raw material was principally brass and iron, and the reduction upon it may, in some measure, be estimated by the diminished price of iron and brass wire, in the cost of which articles, the labor bears a less proportion than it does in many of the others. 5. *The smaller quantity of raw material employed, and perhaps, in some instances, an inferior quality of workmanship.* 6. *The improved means by which the same effect was produced by diminished labor.*

In order to afford the means of estimating the influence of these several causes, the following table is subjoined:

Average Price.	1812.			1818.			1824.		
	£.	s.	d.	£.	s.	d.	£.	s.	d.
Gold, per ounce - - -	4	15	6	4	0	0	3	17	6¼
Value of currency per ct.	79	5	3	97	6	10		100	
Price of 3 per ct. consols		59¾			78½			93¾	
Wheat, per qr. - - -	6	5	0	4	1	0	3	2	1
English pig iron, at Birmingham - - - - -	7	10	0	6	7	6	6	10	0
English bar iron, do. -		. .		10	10	0	9	10	0
Swedish bar iron, in London, excluding duty of from 4*l.* to 6*l.* 10*s.* per ton - - - - -	16	10	0	17	10	0	14	0	0

Average Price.	1828.			1830.			1832.		
	£.	s.	d.	£.	s.	d.	£.	s.	d.
Gold, per ounce - - -	3	17	7	3	17	9¼	3	17	10¼
Value of currency per ct.		100			100			100	
Price of 3 per ct. consols		86			89¾			82½	
Wheat, per qr. - - -	3	11	10	3	14	6	2	19	3
English pig iron, at Birmingham - - - - -	5	10	0	4	10	0	.	.	.
English bar iron, do. -	7	15	0	6	0	0	5	0	0
Swedish bar iron, in London, excluding duty of from 4*l.* to 6*l.* 10*s.* per ton - - - - -	14	10	0	13	15	0	13	2	0

The most influential of these causes has, undoubtedly, been the invention of cheaper modes of manufacturing. The extent to which this can be carried, and yet a profit be realized at the reduced price, is truly astonishing, as the following fact, which rests on good authority, will prove. Twenty years since, a brass knob for the locks of doors was *made* at Birmingham; the price at that time, being 13*s.* 4*d.* per dozen. The same article is now *manufactured*, having the same weight of metal, and an equal, or in fact a slightly superior finish, at 1*s.* 9¼*d.* per dozen. One circumstance which has produced this economy in the *manufacture* is, that the lathe on which these knobs are finished is now turned by a steam-engine; so that the workman, relieved from that labor, can make them twenty times as fast as he did formerly.

150. The difference of price of the same article, when of various dimensions—at different periods, in the same country—and in different countries—is curiously contrasted in the annexed table.

Comparative Price of Plate Glass, at the Manufactories of London, Paris, and Berlin.

Height.	Breadth.	London. 1771.			London. 1794.			London. 1832.		
Inches.	*Inches.*	£.	s.	d.	£.	s.	d.	£.	s.	d.
16	16	0	10	3	0	10	1	0	17	6
30	20	1	14	6	2	3	2	2	6	10
50	30	24	2	4	11	5	0	6	12	10
60	40	67	14	10	27	0	0	13	9	6
76	40	.	.	.	43	6	0	19	2	9
90	50	.	.	.	84	8	0	34	12	9
100	75	.	.	.	275	0	0	74	5	10
120	75	.	.	.	.	.	.	97	15	9

Height.	Breadth.	Paris. 1825.			Berlin. 1828.		
Inches.	*Inches.*	£.	s.	d.	£.	s.	d.
16	16	0	8	7	0	8	11
30	20	1	16	10	1	10	6
50	30	9	4	5	8	13	0
60	40	22	7	5	21	18	6
76	40	36	4	5	35	2	11
90	50	71	3	8	.	.	.
100	75	210	13	3	.	.	.
120	75	354	3	2	.	.	.

The price of silvering these plates is twenty per cent. on the cost price for English glass; ten per cent. on the cost price for Paris plates; and twelve and a half on those of Berlin.

The following table shows the dimensions and price, when silvered, of the largest plates of glass ever made by the British Plate-Glass Company, which are now at their warehouse in London:

Height.	Breadth.	Prices when silvered.		
Inches.	*Inches.*	£.	s.	d.
132	84	200	8	0
146	81	220	7	0
149	84	339	1	6
151	83	239	10	7
160	80	246	15	4

The largest glass in the Paris list, when silvered, and its dimensions and price reduced to English measure, is,

128	80	629	12	0

151. If, therefore, we wish to compare the value of any article at different periods of time, it is clear that neither any one substance, nor even the combination of all manufactured goods, can furnish us with an invariable unit by which to form our scale of estimation. Mr. Malthus has proposed for this purpose to consider a day's labor of an agricultural laborer as the unit to which all value should be referred.

Thus, if we wish to compare the value of twenty yards of broad cloth in Saxony at the present time, with that of the same kind and quantity of cloth fabricated in England two centuries ago, we must find the number of days' labor the cloth would have purchased in England at the time mentioned, and compare it with the number of days' labor twenty yards of the same cloth will now purchase in Saxony. Agricultural labor appears to have been selected, because it exists in all countries, and employs a large number of persons, and also because it requires a very small degree of previous instruction. It seems, in fact, to be merely the exertion of a man's physical force; and its value above that of a machine of equal power arises from its portability, and from the facility of directing its efforts to arbitrary and continually fluctuating purposes. It may perhaps be worthy of inquiry, whether a more constant average might not be deduced from combining with this species of labor those trades which require but a moderate exertion of skill, and which exist in all civilized countries, such as those of the blacksmith and carpenter, &c.* In all such comparisons there is another element, which, though not essentially necessary, will yet add much to our means of judging. It is an estimate of the quantity of that food on which the laborer usually subsists, which is necessary for his daily support, compared with the quantity which his daily wages will purchase.

152. The existence of a class of middle-men between small producers and merchants is frequently advantageous to both parties; and there are certain periods in the history of several manufactures which naturally call that class of traders into existence. There are also other times when the advantage ceasing, the custom of employing them also terminates; the middle-men, especially when numerous, as they sometimes are in retail trades, enhancing the price without equivalent good. Thus, in the recent examination by the House of Commons into the state of the Coal Trade, it appears that five-sixths of the London public is supplied by a class of middle-men who are called in the trade "Brass-plate Coal-Merchants:" these consist principally of merchants' clerks, gentlemen's servants, and others, who have no wharves, but merely give their orders to some true coal-merchant, who sends them in the coals from his wharf. The brass-plate coal-merchant, of course, receives a commission for his agency, which is just so much loss to the consumer.

OF RAW MATERIALS.

153. Although the cost of any article may be reduced in its ultimate analysis to the quantity of labor by which it was produced; yet it is usual, in a certain state of the manufacture of most substances, to call them by the term raw material. Thus, iron, when reduced from the ore and rendered malleable, is in a state of preparation for a multitude of useful purposes, and is the raw material out of which most of our tools are made. In this stage of its manufacture, but a moderate quantity of labor has been expended on the substance; and it becomes an interesting subject to trace the various proportions in which raw material, in this sense of the term, and labor, unite to constitute the value of many of the productions of the arts.

154. Gold-leaf consists of a portion of the metal beaten out to so great a degree of thinness, as to allow a greenish-blue light to be transmitted through its pores. About 400 square inches of this are sold, in the form of a small book containing 25 leaves of gold, for 1*s*. 6*d*. In this case, the raw material, or gold, is worth rather less than two-thirds of the manufactured article. In the case of silver-leaf, the labor considerably exceeds the value of the material. A book of fifty leaves, covering above 1,000 square inches, is sold for 1*s*. 3*d*.

155. In the fine gold chains made at Venice, we may trace in the various prices and sizes the relative influence of the two causes above referred to. The sizes of these chains are known by numbers, the smallest having been (in 1828,) No. 1, and the numbers 2, 3, 4, &c., progressively increasing in size. The following Table shows the numbers and the prices of those made at that time.* The first column is the number by which the chain is known; the second expresses the weight in grains of one inch in length of each chain; the third column shows the number of links in the same length; and the last expresses the price in francs, worth ten-pence each, of a Venetian braccio, or about two English feet of each chain.

No.	Weight of one inch, in grains.	Number of links in one inch.	Price of a Venetian Braccio, equal to two feet ½ inch English.
0	.44	98 to 100	60 francs.
1	.56	92	40
1½	.77	88	26
2	.99	84	20
3	1.46	72	20
4	1.61	64	21
5	2.09	64	23
6	2.61	60	24
7	3.36	56	27
8	3.65	56	29
9	3.72	56	32
10	5.35	50	34
24	9.71	32	60

Amongst these chains, that numbered 0 and that numbered 24 are exactly the same price, although the quantity of gold in the latter is twenty-two times as much as in the former. The difficulty of making the smallest chain is so great, that the women who made it cannot work above two hours at a time. As we advance from the smaller chain, the proportionate value of the work to the worth of the

* Much information for such an inquiry is to be found, for the particular period to which it refers, in the Report of the Committee of the House of Commons on Manufacturers' Employment, 2d July, 1830.

* A still finer chain is now manufactured (1832.)

material becomes less and less, until, at the numbers 2 and 3, these two elements of cost balance each other; after which the difficulty of the work decreases, and the value of the material increases.

156. The quantity of labor applied to these chains is, however, incomparably less than that which is applied to some of the manufactures of iron. In the case of the smallest Venetian chain the value of the labor is not above thirty times that of the gold. The pendulum spring of a watch, which governs the vibrations of the balance, costs at the retail price two-pence, and weighs fifteen one-hundredths of a grain; whilst the retail price of a pound of the best iron, the raw material out of which fifty thousand such springs are made, is exactly the same sum of two-pence.

157. The comparative price of labor and of raw material entering into the manufactures of France, has been ascertained with so much care, in a memoir of M. A. M. Heron de Villefosse, "*Recherches Statistiques, sur les Metaux de France*,' * that we shall give an abstract of his results reduced to English measures. The facts respecting the metals relate to the year 1825.

In France the quantity of raw material which can be purchased for £1, when manufactured into silk goods, is worth £2 37—broad cloth and woollens, 2 15—hemp and cables, 3 94—linen, comprising thread laces, 5 00—cotton goods, 2 44.

The price of pig lead was £1 1 per cwt.; and lead of the value of £1 sterling, became worth, when manufactured into sheets or pipes of moderate dimensions, £1 25—white lead, 2 60—ordinary printing characters, 4 90—the smallest type, 28 30.

The price of copper was £5 2 per cwt. Copper worth £1 became, when manufactured into copper sheeting, £1 26—household utensils, 4 77—common brass pins tinned, 2 34—rolled into plates covered with $\frac{1}{20}$ silver, 3 56—woven into metallic cloth, each square inch of which contains 10,000 meshes, 52 23.

The price of tin was £4 12 per cwt. Tin worth £1, when manufactured into leaves for silvering glass, became £1 73—Household utensils, 1 85.

Quicksilver cost £10 16 per cwt. Quicksilver worth £1, when manufactured into vermillion of average quality, became £1 81.

Metallic arsenic cost £1 4 per cwt. Arsenic worth £1, when manufactured into white oxide of arsenic, became £1 83—sulphate (orpiment), 4 26.

The price of cast iron was 8*s*. per cwt. Cast iron worth £1, when manufactured into household utensils, became £2 00—machinery, 4 00—ornamental, as buckles, &c. 45 00—bracelets, figures, buttons, &c. 147 00.

Bar iron cost £1 6 per cwt. Bar iron worth £1, when manufactured into agricultural instruments, became £3 57—musket barrels, 9 10—barrels of double-barrel guns, twisted and damasked, 238 08—blades of penknives, 657 14—blades of razors, cast steel, 53 57—blades of sabres, for cavalry, infantry, and artillery, &c. from 9 25 to 16 07—blades of table knives, 35 70—buckles of polished steel, used as jewellery, 896 66—clothiers' pins, 8 03—door-latches and bolts, from 4 85 to 8 50—common files, 2 55—flat files, cast steel, 20 44—horse-shoes, 2 55—iron, small slit, for nails, 1 10—metallic cloth, iron wire, No. 80, 96 71—needles of various sizes, from 17 33 to 70 85—reeds for weaving 3-4ths calico, 21 87—saws (frame) of steel, 5 12—saws for wood, 14 28—scissors, finest kind, 446 94—sword handles, polished steel, 972 82—cast steel, 4 28—steel cast in sheets, 6 25—cemented steel, 2 41—natural steel, 1 42—tinned iron, from 2 04 to 2 34—iron wire, from 2 14 to 10 17.

158. The following is stated by M. de Villefosse to be the price of bar iron at the forges of various countries, in January, 1825:

	Per ton.
France, ...	£26 10 0
Belgium and Germany, . .	16 14 0
Sweden and Russia, at Stockholm and St. Petersburg, . .	13 13 0
England, at Cardiff, . . .	10 1 0
The price of the article in 1832, was	5 0 0

M. de Villefosse states that in France, bar iron, made as it usually is with charcoal, costs three times the price of the cast iron out of which it is made; whilst in England, where it is usually made with coke, the cost is only twice the price of cast iron.

ON THE DIVISION OF LABOR.

159. Perhaps the most important principle on which the economy of a manufacture depends, is the *division of labor* amongst the persons who perform the work. The first application of this principle must have been made in a very early stage of society, for it must soon have been apparent that more comforts and conveniences could be acquired by one man restricting his occupation to the art of making bows, another to that of building houses, a third boats, and so on. This division of labor into trades was not, however, the result of an opinion that the general riches of the community would be increased by such an arrangement: but it must have arisen from the circumstance of each individual so employed discovering that he himself could thus make a greater profit of his labor than by pursuing more varied occupations. Society must have made considerable advances before this principle could have been carried into the workshop; for it is only in countries which have attained a high degree of civilization, and in articles in which there is a great competition amongst the producers, that the most perfect system of the division of labor is to be observed. The principles on which the advantages of this system

* Memoires de l'Institut. 1826.

depend have been much the subject of discussion amongst writers of political economy ; but the relative importance of their influence does not appear, in all cases, to have been estimated with sufficient precision. It is my intention, in the first instance, to state shortly those principles, and then to point out what appears to me to have been omitted by those who have previously treated the subject.

160. First. *Of the time required for learning.* It will readily be admitted, that the portion of time occupied in the acquisition of any art will depend on the difficulty of its execution ; and that the greater the number of distinct processes, the longer will be the time which the apprentice must employ in acquiring it. Five or seven years have been adopted, in a great many trades, as the time considered requisite for a lad to acquire a sufficient knowledge of his art, and to repay by his labor, during the latter portion of his time, the expense incurred by his master at its commencement. If, however, instead of learning all the different processes for making a needle, for instance, his attention be confined to one operation, a very small portion of his time will be consumed unprofitably at the commencement, and the whole of the rest of it will be beneficial to his master ; and if there be any competition amongst the masters, the apprentice will be able to make better terms, and diminish the period of his servitude. Again : the facility of acquiring skill in a single process, and the early period of life at which it can be made a source of profit, will induce a greater number of parents to bring up their children to it ; and from this circumstance, also, the number of workmen being increased, the wages will soon fall.

161. A certain quantity of material will be consumed unprofitably, or spoiled, by every person who learns an art ; and, as he applies himself to each new process, he will waste a certain quantity of the raw material, or of the partly manufactured commodity. But whether one man commits this waste in acquiring successively each process, or many persons separately learn the several processes, the quantity of waste will remain the same : in this view of the subject, therefore, the division of labor will neither increase nor diminish the price of the production.

162. Second. Another source of the advantage resulting from the division of labor is, that time is always lost from changing from one occupation to another. When the human hand, or the human head, has been for some time occupied in any kind of work, it cannot instantly change its employment with full effect. The muscles of the limbs employed have acquired a flexibility during their exertion—and those to be put in action, a stiffness during rest—which renders every change slow and unequal in the commencement. A similar result seems to take place in any change of mental exertion ; the attention bestowed on the new subject is not so perfect at the first commencement as it becomes after some exercise. Long habit also produces in the muscles exercised a capacity for enduring fatigue to a much greater degree than they could support under other circumstances.

163. Another cause of the loss of time in changing from one operation to another, arises from the employment of different tools in the two processes. If these tools are simple in their nature, and the change is not frequently repeated, the loss of time is not considerable ; but in many processes of the arts the tools are of great delicacy, requiring accurate adjustment whenever they are used. In many cases the time employed in adjusting, bears a large proportion to that employed in using the tool. The sliding-rest, the dividing and the drilling engine, are of this kind ; and hence in manufactories of sufficient extent, it is found to be good economy to keep one machine constantly employed in one kind of work : one lathe, for example, having a screw motion to its sliding-rest along the whole length of its bed, is kept constantly making cylinders ; another, having a motion for rendering uniform the velocity of the work at the point at which it passes the tool, is kept for facing surfaces ; whilst a third is constantly employed in cutting wheels.

164. Third. *Skill acquired by frequent repetition of the same processes.* The constant repetition of the same process necessarily produces in the workman a degree of excellence and rapidity in his particular department, which is never possessed by one person who is obliged to execute many different processes. This rapidity is still farther increased, from the circumstance that most of the operations in factories, where the division of labor is carried to a considerable extent, are paid for as piece work. It is difficult to estimate in numbers the effect of this cause upon production. In nail-making, Adam Smith has stated that it is almost three to one ; for, he observes, that a smith accustomed to make nails, but whose whole business has not been that of a nailer, can make only from eight hundred to a thousand per day ; whilst a lad, who had never exercised any other trade, can make upwards of two thousand three hundred a day.

165. Upon an occasion when a large issue of bank-notes was required, a clerk at the Bank of England signed his name, consisting of seven letters, including the initial of his Christian name, five thousand three hundred times during eleven working hours ; and he also arranged the notes he had signed in parcels of fifty each. In different trades, the economy of production arising from this cause will necessarily be different. The case of nail-making is, perhaps, rather an extreme one. It must, however, be observed that, in one sense, this is not a permanent source of advantage ; for, although it acts at the commencement of an establishment, yet every month adds to the skill of the workmen ; and at the end of three or four years they will not be very far behind those

who have practised only the particular branch of their art.

166. Fourth. *The division of labor suggests the contrivance of tools and machinery to execute its processes.* When each process, by which any article is produced, is the sole occupation of one individual, his whole attention being devoted to a very limited and simple operation, any improvement in the form of his tools, or in the mode of using them, is much more likely to occur to his mind than if it were distracted by a greater variety of circumstances. Such an improvement in the tool is generally the first step towards a machine. If a piece of metal is to be cut in a lathe, for example, there is one angle at which the cutting-tool must be held to insure the cleanest cut; and it is quite natural that the idea of fixing the tool at that angle should present itself to an intelligent workman. The necessity of moving the tool slowly, and in a direction parallel to itself, would suggest the use of a screw, and thus arises the sliding-rest. It was probably the idea of mounting a chisel in a frame, to prevent its cutting too deeply, which gave rise to the common carpenter's plane. In cases where a blow from a hammer is employed, experience teaches the proper force required. The transition from the hammer held in the hand to one mounted upon an axis, and lifted regularly to a certain height by some mechanical contrivance, requires perhaps a greater degree of invention. Yet it is not difficult to perceive, that, if the hammer always falls from the same height, its effect must be always the same.

167. When each process has been reduced to the use of some simple tool, the union of all these tools, actuated by one moving power, constitutes a machine. In contriving tools and simplifying processes, the operative workmen are, perhaps, most successful; but it requires far other habits to combine into one machine these scattered arts. A previous education as a workman in the peculiar trade is undoubtedly a valuable preliminary; but in order to make such combinations with any reasonable expectation of success, an extensive knowledge of machinery and the power of making mechanical drawings are essentially requisite. These accomplishments are now much more common than they were formerly; and their absence was, perhaps, one of the causes of the multitude of failures in the early history of many of our manufactures.

168. Such are the principles usually assigned as the causes of the advantages resulting from the division of labor. As in the view I have taken of the question, the most important and influential cause has been altogether unnoticed, I shall re-state those principles in the words of Adam Smith: "The great increase in the quantity of work, which, in consequence of the division of labor, the same number of people are capable of performing, is owing to three different circumstances: first, to the increase of dexterity in every particular workman; secondly, to the saving of time, which is commonly lost in passing from one species of work to another; and, lastly, to the invention of a great number of machines, which facilitate and abridge labor, and enable one man to do the work of many." Now, although all these are important causes, and each has its influence on the result, yet it appears to me, that any explanation of the cheapness of manufactured articles, as consequent upon the division of labor, would be incomplete if the following principle were omitted to be stated.

That the master manufacturer, by dividing the work to be executed into different processes, each requiring different degrees of skill and force, can purchase exactly that precise quantity of both which is necessary for each process; whereas, if the whole work were executed by one workman, that person must possess sufficient skill to perform the most difficult, and sufficient strength to execute the most laborious, of the operations into which the art is divided.*

169. As the clear apprehension of this principle, upon which so much of the economy arising from the division of labor depends, is of considerable importance, it may be desirable to illustrate it, by pointing out its precise and numerical application in some specific manufacture. The art of making needles is, perhaps, that which I should have selected as comprehending a very large number of processes remarkably different in their nature; but the less difficult art of pin-making has some claim to attention, from its having been used by Adam Smith, in his illustration of the subject; and I am confirmed in the choice, by the circumstance of our possessing a very accurate and minute description of that art, as practised in France above half a century ago.

170. *Pin-making.* In the manufacture of pins in England, the following processes are employed:

1. *Wire-drawing.* The brass wire used for making pins is purchased by the manufacturer in coils of about twenty-two inches in diameter, each weighing about thirty-six pounds. The coils are wound off into smaller ones of about six inches in diameter, and between one and two pounds' weight. The diameter of this wire is now reduced by drawing it repeatedly through holes in steel plates, until it becomes of the size required for the sort of pins intended to be made. During the process of drawing the wire through these holes it becomes hardened, and it is necessary to anneal it in order to prevent its breaking; and to enable it to be still farther reduced it is annealed two or three times, according to the diminution of diameter required. The coils are then soaked in sulphuric acid, largely diluted with water, in order

* I have already stated, that this principle presented itself to me after a personal examination of a number of manufactories and work-shops devoted to different purposes; but I have since found that it has been distinctly stated in the work of Gioja. Nuovo Prospetto delle Scienze Economiche, 6 tom. 4to. Milano, 1815, tom. i. capo iv.

to clean them, and are then beaten on stone for the purpose of removing any oxidated coating which may adhere to them. This process is usually performed by men, who draw and clean from thirty to thirty-six pounds of wire a day. They are paid at the rate of five farthings per pound, and generally earn about 3*s*. 6*d*. per day.

M. Perronet made some experiments on the extension the wire undergoes by this process at each hole: he took a piece of thick Swedish brass wire, and found its length to be before drawing, 3 feet 8 inches—after passing the first hole, 5 feet 7 inches—after passing the second hole, 7 feet 2 inches—and after passing the third hole, 7 feet 8 inches.

It was now annealed, and the length became after passing the fourth hole, 10 feet 8 inches—after passing the fifth hole, 13 feet 1 inch—after passing the sixth hole, 16 feet 8 inches—and finally, after passing through six other holes, 144 feet.

The holes through which the wire was drawn were not, in this experiment, of regular decreasing diameter; and it is extremely difficult to make such holes, and still more to preserve them in their original dimensions.

171. II. *Straightening Wire.* The coil of wire now passes into the hands of a woman, assisted by a boy or girl. A few nails, or iron pins, not quite in a line, are fixed into one end of a wooden table about twenty feet in length; the end of the wire is passed alternately between these nails, and is then pulled to the other end of the table. The object of this process is to straighten the wire, which had acquired a uniform curvature in the small coils into which it had been wound. The length thus straightened is cut off, and the remainder of the coil is drawn into similar lengths. About seven nails or pins are employed in straightening the wire, and their adjustment is a matter of some nicety. It seems that, by passing the wire between the first three nails or pins, a bend is produced in an opposite direction to that which the wire had in the coil; this bend, by passing the next two nails, is reduced to another of larger curvature in the first direction, and so on till the curvature is at last so large that it may be confounded with a straight line.

172. III. *Pointing.* A man next takes about three hundred of these straightened pieces in a parcel, and, putting them into a gauge, cuts off from one end, by means of a pair of shears, moved by his foot, a portion equal in length to rather more than six pins. He continues this operation until the entire parcel is reduced into similar pieces. The next step is to sharpen the ends: for this purpose the operator sits before a steel mill, which is kept rapidly revolving; and taking up a parcel between the finger and thumb of each hand, he passes the ends before the mill, taking care with his fingers and thumbs to make each wire slowly revolve upon its axis. The mill consists of a cylinder about six inches in diameter, and two and a half inches broad, faced with steel, which is cut in the manner of a file. Another cylinder is fixed on the same axis at a few inches distant; the file on the edge of which is of a finer kind, and is used for finishing off the points. Having thus pointed all the pieces at one end, he reverses them, and performs the same process on the other. This process requires considerable skill, but it is not unhealthy; whilst the similar process in needle-making is remarkably destructive of health. The pieces, now pointed at both ends, are next placed in gauges, and the pointed ends are cut off, by means of shears, to the proper length of which the pins are to be made. The remaining portions of the wire are now equal to about four pins in length, and are again pointed at each end, and their ends again cut off. This process is repeated a third time, and the small portion of wire left in the middle is thrown amongst the waste, to be melted along with the dust arising from the sharpenings. It is usual for a man, his wife, and a child, to join in performing these processes; and they are paid at the rate of five farthings per pound. They can point from thirty-four to thirty-six and a half pounds per day, and gain from 6*s*. 6*d*. to 7*s*., which may be apportioned thus: 5*s*. 6*d*. the man, 1*s*. the woman, 6*d*. to the boy or girl.

173. IV. *Twisting and Cutting the Heads.* The next process is making the heads. For this purpose a boy takes a piece of wire, of the same diameter as the pin to be headed, which he fixes on an axis that can be made to revolve rapidly by means of a wheel and strap connected with it. This wire is called the mould. He then takes a smaller wire, which, having passed through an eye in a small tool held in his left hand, he fixes close to the bottom of the mould. The mould is now made to revolve rapidly by means of the right hand, and the smaller wire coils round it until it has covered the length of the mould. The boy now cuts the end of the spiral connected with the foot of the mould, and draws it off. When a sufficient quantity of heading is thus made, a man takes from thirteen to twenty of these spirals in his left hand, between his thumb and three outer fingers; these he places in such a manner that two turns of the spiral shall be beyond the upper edge of a pair of shears, and with the fore-finger of the same hand he feels these two projecting turns. With his right hand he closes the shears; and the two turns of the spiral being cut off, drop into a basin. The position of the fore-finger prevents the heads from flying about when cut off. The workmen who cut the heads are usually paid at the rate of 2½*d*. to 3*d*. per pound for large, but a higher price is given for the smaller heading. Out of this they pay the boy who spins the spiral; he receives from 4*d*. to 6*d*. per day. A good workman can cut from six to about thirty pounds of heading per day, according to its size.

174. V. *Heading.* The process of fixing

the head on the body of the pin is usually executed by women and children. Each operator sits before a small steel stake, having a cavity, into which one half of the intended head will fit; immediately above is a steel die, having a corresponding cavity for the other half of the head: this latter die can be raised by a pedal moved by the foot. The cavities in the centre of these dies are connected with the edge by a small groove, to admit of the body of the pin, which is thus prevented from being flattened by the blow of the die. The operator with his left hand dips the pointed end of the body of a pin into a tray of heads; having passed the point through one of them, he carries it along to the other end with the fore-finger. He now takes the pin in the right hand, and places the head in the cavity of the stake, and, lifting the die with his foot, allows it to fall on the head. This blow tightens the head on the shank, which is then turned round, and the head receives three or four blows on different parts of its circumference. The women and children who fix the heads are paid at the rate of 1*s.* 6*d.* for every twenty thousand. A skilful operator can with great exertion do twenty thousand per day, but from ten to fifteen thousand is the usual quantity; children head a much smaller number, varying, of course, with the degree of their skill. The weight of the hammer is from seven to ten pounds, and it falls through a very small space, perhaps from one to two inches. About one per cent. are spoiled in the process; these are picked out afterwards by women, and reserved with the waste from other processes for the melting-pot. The form of the dies in which the heads are struck is varied according to the fashion of the time; but the repeated blows to which it is subject renders it necessary that it should be repaired after it has been used for about thirty pounds of pins.

175. VI. *Tinning.* The pins are now fit to be tinned, a process which is usually executed by a man, assisted by his wife, or by a lad. The quantity of pins operated upon at this stage is usually fifty-six pounds. They are first placed in a pickle, in order to remove any grease or dirt from their surface, and also to render that surface rough, which facilitates the adherence of the tin with which they are to be covered. They are then placed in a boiler full of a solution of tartar and water, in which they are mixed with a quantity of tin in small grains. They are generally kept boiling for about two hours and a half, and are then removed into a tub of water, into which some bran has been thrown: this is for the purpose of washing them. They are then taken out, and, being placed in wooden trays, are well shaken in dry bran: this removes any water adhering to them; and by giving the wooden tray a peculiar kind of motion, the pins are thrown up, and the bran gradually flies off, and leaves them behind in the tray. The man who pickles and tins the pins usually gets one penny per pound for the work, and employs himself, during the boiling of one batch of pins, with drying those previously tinned. He can earn about 9*s.* per day; but out of this he pays about 3*s.* for his assistant.

176. VII. *Papering.* The arranging of pins side by side in paper is generally performed by women. The pins come from the last process in wooden bowls, with the points projecting in all directions. A woman takes up some, and places them on the teeth of a comb, whilst, by a few shakes, some of the pins fall back into the bowl, and the rest, being caught by their heads, are detained between the teeth of the comb. Having thus arranged them in a parallel direction, she fixes the requisite number between two pieces of iron, having twenty-five small grooves, at equal distances; and having previously doubled the paper, she presses it against the points of the pins until they have passed through the two folds which are to retain them. The pins are then relieved from the grasp of the tool, and the process repeated with others. A woman gains about 1*s.* 6*d.* per day by papering; but children are sometimes employed, who earn from 6*d.* per day, and upwards.

177. Having thus described the various processes of pin-making, without entering into the minuter details, and having stated the usual cost of each, it will be convenient to present a tabular view of the time occupied by each process, and its cost, as well as of the sums which can be earned by the persons who confine themselves solely to each process. As the rate of wages is itself fluctuating, and as the prices paid and quantities executed have been given between certain limits, it is not to be expected that this table can represent with the minutest accuracy the cost of each part of the work, nor even that it shall accord perfectly with the prices above given: but it has been drawn up with some care, and will be quite sufficient for that general view, and for those reasonings which it is meant to illustrate. A table nearly similar will be subjoined, which has been deduced from a statement of M. Perronet, respecting the art of pin-making in France, about seventy years ago.

178. *English Manufacture.*—Pins, "*Elevens,*" 5,546 weigh one pound; "*one dozen,*" = 6,932 pins, weigh twenty ounces, and require six ounces of paper.

Names of the Process.	Workmen.	Time of making 1 lb.	Cost of making 1 lb.	Workman earns pr day.	Price of making each part of a pin in 1,000,000 of 1d.
		Hours.	Pence.	s. d.	
1. Drawing Wire, (§ 170)	Man	.3636	1.2500	3 3	225
2. Straightening of the wire (§ 171)	Woman	.3000	.2840	1 0	51
	Girl	.3000	.1420	0 6	26
3. Pointing (§ 172)	Man	.3000	1.7750	5 3	319
4. Twisting and cutting the Heads (§ 173)	Boy	.0400	.0147	0 4½	3
	Man	.0400	.2103	5 4½	33
5. Heading (§ 174)	Woman	4.0000	5.0000	1 3	901
6. Tinning, or Whitening (§ 175)	Man	.1071	.6666	6 0	121
	Woman	.1071	3333	3 0	60
7. Papering (§ 176)	Woman	2.1314	3.1973	1 6	576
		7.6892	12.8732		2320

Number of persons employed: Men, 4; Women, 4; Children 2. Total, 10.

179. *French Manufacture.*—Cost of 12,000 pins, N. 6, each being eight-tenths of an English inch in length; with the cost of operation,—deduced from the observations and statement of M. Perronet,—as they were manufactured in France about 1760.

Names of the Process.	Time of making 12,000 pins.	Cost of making 12,000 pins.	Workmn usually earns pr day.	Expense of tools and materials.
	Hours.	Pence.	Pence.	Pence.
1. Wire				24.75
2. Straightening and cutting	1.2	.5	4.5	
3. Coarse Pointing	1.2	.625	10.0	
Turning Wheel*	1.2	.875	7.0	
Fine Pointing	.8	.5	9.375	
Turning Wheel	1.2	.5	4.75	
Cutting off pointed ends	.6	.375	7.5	
4. Turning Spiral	.5	.125	3.0	
Cutting off Heads	.8	.375	5.625	
Fuel to anneal ditto				.125
5. Heading	12.0	.333	4.25	
6. Tartar for cleaning				.5
Tartar for whitening				.5
7. Papering	4.8	5	2.0	
Paper				1.0
Wear of Tools				2.0
	24.3	4.708		

180. It appears from the analysis we have given of the art of pin-making, that it occupies rather more than seven hours and a half of time, for ten different individuals working in succession on the same material, to convert it into a pound of pins; and that the total expense of their labor, each being paid in the joint ratio of his skill and of the time he is employed, amounts very nearly to 1*s.* 1*d.* But from an examination of the first of these tables, it appears that the wages earned by the persons employed vary from 4½*d.* per day to 6*s.*, and consequently the skill which is required for their respective employments may be measured by those sums. Now it is evident, that if one person be required to make the whole pound of pins, he must have skill enough to earn about 5*s.* 3*d.* per day whilst he is pointing the wires or cutting off the heads from the spiral coil—and 6*s.* when he is whitening the pins: which three operations together would occupy little more than the seventeenth part of his time. It is also apparent, that during more than one half of his time he must be earning only 1*s.* 3*d.* per day in putting on the heads, although his skill, if properly employed, would, in the same time, produce nearly five times as much. If, therefore, we were to employ, for each of the processes, the man who whitens the pins, and who earns 6*s.* per day, even supposing that he could make the pound of pins in an equally short time, yet we must pay him for his time 46.14 pence, or about 3*s.* 10*d.* The pins would, therefore, cost in making, three times and three quarters as much as they now do by the application of the division of labor. The higher the skill required of the workman in any one process of a manufacture, and the smaller the time during which it is employed, so much the greater will be the advantage of separating that process from the rest, and devoting one person's attention entirely to it. Had we selected the art of needle-making as our illustration, the economy arising from the division of labor would have been still larger, for the process of tempering the needles requires great skill, attention, and experience; and although from three to four thousand are tempered at once, the workman is paid a very high rate of wages. In another process of the same art, dry-pointing, which is also executed with great rapidity, the wages earned by the workman reach from 7*s.* to 12*s.*, 15*s.*, and even, in some instances, to 20*s.* a day; whilst other processes in the same art are carried on by children paid at the rate of 6*d.* per day.

181. Some farther reflections are suggested by the preceding analysis; but it may be convenient, previously, to place before the reader a brief description of a machine for making pins, invented by an American. It is highly ingenious in point of contrivance, and, in respect to its economical principles, will furnish a strong and interesting contrast with the manufacture of pins by the human hand. In this machine a coil of brass wire is placed on an axis; one end of this wire is drawn by a pair of rollers through a small hole in a plate of steel, and is held there by a forceps. As soon as the machine is put in action—

1. The forceps draws the wire on to a distance equal in length to one pin: a cutting edge of steel then descends close to the hole through which the wire entered, and severs a piece equal in length to one pin.

2. The forceps holding this wire moves on until it brings the wire into the centre of the *chuck* of a small lathe, which opens to receive it. Whilst the forceps returns to fetch another piece of wire, the lathe revolves rapidly, and grinds the projecting end of the wire upon a steel mill, which advances towards it.

3. After this first or coarse pointing, the lathe stops, and another forceps takes hold of the half-pointed pin, (which is instantly released by the opening of the *chuck*,) and conveys it to a similar *chuck* of another lathe, which receives it, and finishes the pointing on a finer steel mill.

4. This mill again stops, and another forceps removes the pointed pin into a pair of strong steel clams, having a small groove in them, by which they hold the pin very firmly. A part of this groove, which terminates at that edge of the steel clams which is intended to form the head of the pin, is made conical. A small round steel punch is now driven forcibly against the end of the wire thus clamped, and the head of

* The expense of turning the wheel appears to have arisen from the person so occupied being unemployed during half his time, whilst the pointer went to another manufactory

a pin is partially formed by compressing the wire into the conical cavity.

5. Another pair of forceps now removes the pin to another pair of clams, and the head of the pin is completed by a blow from a second punch, the end of which is slightly concave. Each pair of forceps returns as soon as it has delivered its burden; and thus there are always five pieces of wire at the same moment in different stages of advance towards a finished pin. The pins so formed are received in a tray, and whitened and papered in the usual manner. About sixty pins can thus be made by this machine in one minute; but each process occupies exactly the same time in performing.

182. In order to judge of the value of such a machine, compared with hand labor, it would be necessary to inquire: 1. To what defects pins so made are liable? 2. What advantages they possess over those made in the usual way? 3. What is the prime cost of a machine for making them? 4. What is the expense of keeping it in repair? 5. What is the expense of moving it and attending to it?

1. Pins made by the machine are more likely to bend, because as the head is punched up out of the solid wire, it ought to be in a soft state to admit of this process. 2. Pins made by the machine are better than common ones, because they are not subject to losing their heads. 3. With respect to the prime cost of a machine, it would be very much reduced if numbers should be required. 4. With regard to its wear and tear, experience only can decide the question: but it may be remarked, that the steel clams or dies in which the heads are punched up will wear quickly, unless the wire has been softened by annealing; and that if it has been softened, the bodies of the pins will bend too readily. Such an inconvenience might be remedied, either by making the machine spin the heads and fix them on, or by annealing only that end of the wire which is to become the head of the pin: but this would cause a delay between the operations, since the brass is too brittle while heated to bear a blow without crumbling. 5. On comparing the time occupied by the machine with that stated in the analysis, we find, except in the process of heading, if time alone is considered, that the human hand is more rapid. Three thousand six hundred pins are pointed by the machine in an hour, whilst a man can point fifteen thousand six hundred in the same time. But in the process of heading, the rapidity of the machine is two and a half times that of the human hand. It must, however, be observed, that the process of grinding does not require the application of force to the machine equal to that of one man; for all the processes we have described are executed at once by the machine, and one laborer can easily work it.

ON THE DIVISION OF MENTAL LABOR.

183. We have already mentioned what may, perhaps, appear paradoxical to some of our readers,—that the division of labor can be applied with equal success to mental operations, and that it insures, by its adoption, the same economy of time. A short account of its practical application, in the most extensive series of calculations ever executed, will offer an interesting illustration of this fact, whilst at the same time it will afford an occasion for showing that the arrangements which ought to regulate the interior economy of a manufactory are founded on principles of deeper root than may have been supposed, and are capable of being usefully employed in paving the road to some of the sublimest investigations of the human mind.

184. In the midst of that excitement which accompanied the Revolution of France and the succeeding wars, the ambition of the nation, unexhausted by its fatal passion for military renown, was at the same time directed to the nobler and more permanent triumphs which mark the era of a people's greatness,—and which receive the applause of posterity long after their conquests have been wrested from them, or even when their existence as a nation may be told only by the page of history. Amongst their enterprizes of science, the French government was desirous of producing a series of mathematical tables, which should facilitate the extension of the decimal system they had so recently adopted. They directed, therefore, their mathematicians to construct such tables, on the most extensive scale. Their most distinguished philosophers, responding fully to the call of their country, invented new methods for this laborious task; and a work, completely answering the large demands of the government, was produced in a remarkably short period of time. M. Prony, to whom the superintendance of this great undertaking was confided, in speaking of its commencement, observes: "Je m'y livrai avec toute l'ardeur dont j'etois capable, et je m'occupai d'abord du plan general de l'execution. Toutes les conditions que j'avois à remplir necessitoient l'emploi d'un grand nombre de calculateurs; et il me vint bientot à la pensee d'appliquer à la confection de ces tables *la division du travail,* dont les Arts de Commerce tirent un parti si avantageux pour reunir à la perfection de main-d'œuvre l'economie de la depense et du temps." The circumstance which gave rise to this singular application of the principle of *the division of labor* is so interesting, that no apology is necessary for introducing it from a small pamphlet printed at Paris a few years since, when a proposition was made by the English to the French government, that the two countries should print these tables at their joint expense.

185. The origin of the idea is related in the following extract:

C'est à un chapitre d'un ouvrage Anglais, justement celebre, (I.) qu'est probablement due l'existence de l'ouvrage dont le gouvernement Britannique veut faire jouir le monde savant:

[*An Inquiry into the Nature and Causes of the Wealth of Nations, by Adam Smith,*]

Voici l'anecdote : M. de Prony s'etait engage, avec les comites de gouvernement, a composer pour la division centesimale du cercle, des tables logarithmiques et trigonometriques, qui, non seulement ne laissassent rien a desirer quant a l'exactitude, mais qui formassent le monument de calcul le plus vaste et le plus imposant qui eut jamais ete execute, ou meme concu. Les logarithmes des nombres de 1 a 200,000 formaient a ce travail un supplement necessaire et exige. Il fut aise a M. de Prony de s'assurer que, meme en s'associant trois ou quatre habiles co-operateurs, la plus grande duree presumable de sa vie, ne lui suffirai pas pour remplir ses engagements. Il etait occupe de cette facheuse pensee lorsque, se trouvant devant la boutique d'un marchand de livres, il appercut la belle edition Anglaise de Smith, donnee a Londres en 1776 ; il ouvrit le livre au hazard, et tomba sur le premier chapitre, qui traite de *la division du travail*, et ou la fabrication des epingles est citee pour exemple. A peine avait-il parcouru les premieres pages, que, par une espece d'inspiration, il concut l'expedient de mettre ses logarithmes en *manufacture* comme les epingles. Il faisait, en ce moment, a l'ecole polytechnique, des lecons sur une partie d'analyse liee a ce genre de travail, *la methode des differences*, et ses applications a *l'interpolation*. Il alla passer quelques jours a la campagne, et revint a Paris avec le plan de *fabrication*, qui a ete suivi dans l'execution. Il rassembla deux ateliers, qui faisaient separement les memes calculs, et se servaient de verification reciproque.*

186. The ancient methods of computing tables were quite inapplicable to such a proceeding. M. Prony, therefore, wished to avail himself of all the talent of his country, and formed the first section of those who were to take part in this enterprize, out of five or six of the most eminent mathematicians in France.

First Section.—The duty of this first section was to investigate, amongst the various analytical expressions which could be found for the same function, that which was most readily adapted to simple numerical calculation by many individuals employed at the same time. This section had little or nothing to do with the actual numerical work. When its labors were concluded, the formulæ, on the use of which it had decided, were delivered to the second section.

Second Section.—This section consisted of seven or eight persons of considerable acquaintance with mathematics : and their duty was to convert into numbers the formulæ put into their hands by the first section—an operation of great labor—and then to deliver out these formulæ to the members of the third section, and receive from them the finished calculations. The members of this second section had certain means of verifying these calculations without the necessity of repeating, or even of examining, the whole of the work done by the third section.

Third Section.—The members of this section, whose number varied from sixty to eighty, received certain numbers from the second section, and, using nothing more than simple addition and subtraction, they returned to that section the finished tables. It is remarkable that nine-tenths of this class had no knowledge of arithmetic beyond its two first rules which they were thus called upon to exercise, and that these persons were usually found more correct in their calculations than those who possessed a more extensive knowledge of the subject.

187. When it is stated that the tables thus computed occupy seventeen large folio volumes, some idea may perhaps be formed of the labor. From that part executed by the third class, which may almost be termed mechanical, requiring the least knowledge and by far the greatest labor, the first class were entirely exempt. Such labor can always be purchased at an easy rate. The duties of the second class, although requiring considerable skill in arithmetical operations, were yet in some measure relieved by the higher interest naturally felt in those more difficult operations. The exertions of the first class are not likely to require, upon another occasion, so much skill and labor as they did upon the first attempt to introduce such a method ; but when the completion of a calculating engine shall have produced a substitute for the whole of the third section of computers, the attention of analysts will naturally be directed to simplifying its application, by a new discussion of the methods of converting analytical formulæ into numbers.

188. The proceeding of M. Prony, in this celebrated system of calculation, much resembles that of a skilful person about to construct a cotton or silk mill, or any similar establishment. Having, by his own genius, or through the aid of his friends, found that some improved machinery may be successfully applied to his pursuit, he makes drawings of his plans of the machinery, and may himself be considered as constituting the first section. He next requires the assistance of operative engineers, capable of executing the machinery he has designed, some of whom should understand the nature of the processes to be carried on ; and these constitute his second section. When a sufficient number of machines have been made, a multitude of other persons, possessed of a lower degree of skill, must be employed in using them ; these form the third section : but their work and the just performance of the machines must be still superintended by the second class.

189. As the possibility of performing arithmetical calculations by machinery may appear to non-mathematical readers to be rather too large a postulate, and as it is connected with the subject of the *division of labor*, I shall here endeavor, in a few lines, to give some sligh*

* Note sur la publication, proposee par le gouvernement Anglais, des grandes tables logarithmiques et trigonometriques de M. de Prony. De l'imprimerie de F. Didot, Dec. 1, 1820, p. 7.

perception of the manner in which this can be done—and thus to remove a small portion of the veil which covers that apparent mystery.

190. That nearly all tables of numbers which follow any law, however complicated, may be formed, to a greater or less extent, solely by the proper arrangement of the successive addition and subtraction of numbers befitting each table, is a general principle which can be demonstrated to those only who are well acquainted with mathematics; but the mind, even of the reader who is but very slightly acquainted with that science, will readily conceive that it is not impossible, by attending to the following example. Let us consider the subjoined table. This table is the beginning of one in very extensive use, which has been printed and reprinted very frequently in many countries, and is called *a table of square numbers.*

Terms of the table.	A. Table.	B. 1st Difference.	C. 2d Difference.
1	1		
		3	
2	4		2
		5	
3	9		2
		7	
4	16		2
		9	
5	25		2
		11	
6	36		2
		13	
7	40		

Any number in the table, column A, may be obtained, by multiplying the number which expresses the distance of that term from the commencement of the table by itself; thus, 25 is the fifth term from the beginning of the table, and 5 multiplied by itself, or by 5, is equal to 25. Let us now subtract each term of this table from the next succeeding term, and place the results in another column, (B,) which may be called first difference column. If we again subtract each term of this first difference from the succeeding term, we find the result is always the number 2, (column C;) and that the same number will always recur in that column, which may be called the second difference, will appear to any person who will take the trouble to carry on the table a few terms farther. Now when once this is admitted as a known fact, it is quite clear that, provided the first term (1) of the table, the first term (3) of the first differences, and the first term (2) of the second or constant difference, are originally given, we can continue the table of square numbers to any extent, merely by simple addition: for the series of the first differences may be formed by repeatedly adding the constant difference 2 to (3) the first number in column B, and we then necessarily have the series of odd numbers, 3, 5, 7, &c.: and, again, by successively adding each of these to the first number (1) of the table, we produce the square numbers.

191. Having thus, I hope, thrown some light upon the theoretical part of the question, I shall endeavor to show that the mechanical execution of such an engine, as would produce this series of numbers, is not so far removed from that of ordinary machinery as might be conceived. Let the reader imagine three clocks placed on a table side by side, each having only one hand, and each having a thousand divisions instead of twelve hours marked on the face; and every time a string is pulled, let them strike on a bell the numbers of the divisions to which their hands point. Let him farther suppose, that two of the clocks, for the sake of distinction called B and C, have some mechanism by which the clock C advances the hand of the clock B one division, for each stroke it makes upon its own bell; and let the clock B, by a similar contrivance, advance the hand of the clock A one division, for each stroke it makes on its own bell. With such an arrangement, having set the hand of the clock A to the division I., that of B to III., and that of C to II., let the reader imagine the repeating parts of the clocks to be set in motion continually, in the following order, viz.: pull the string of clock A; pull the string of clock B; pull the string of clock C.

Repetitions of process.	Movements.	Clock A. — Hand set to I.	Clock B. — Hand set to III.	Clock C. — Hand set to II.
		Table	1st difference	2d diffrence
1	Pull A.	A. strikes.....1	....	....
	—— B.	The hand is advanced (by B.) 3 divisions	B. strikes.....3	....
	—— C.	....	The hand is advanced (by C.) 2 divisions.....	C. strikes 2
2	Pull A.	A. strikes....4	....	....
	—— B.	The hand is advanced (by B.) 5 divisions.....	B. strikes.....5	....
	—— C.	....	The hand is advanced (by C.) 2 divisions.....	C. strikes 2
3	Pull A.	A. strikes.....9	....	....
	—— B.	The hand is advanced (by B.) 7 divisions.....	B. strikes.....7	....
	—— C.	....	The hand is advanced (by C.) 2 divisions.....	C. strikes 2
4	Pull A.	A. strikes....16	....	....
	—— B.	The hand is ad vanced (by B.) 9 divisions.....	B. strikes.....9	....
	—— C.	....	The hand is advanced (by C.) 2 divisions.....	C. strikes 2

If now only those divisions struck or pointed at by the clock C be attended to and written down, it will be found that they produce the series of the squares of the natural numbers.

Such a series could, of course, be carried by this mechanism only so far as the three first figures; but this may be sufficient to give some idea of the construction, and was, in fact, the point to which the first model of the calculating-engine, now in progress, extended.

192. We have seen, then, that the effect of the *division of labor*, both in the mechanical and mental processes, is, that it enables us to purchase and apply to each process precisely that quantity of skill and knowledge which is required for it: we avoid employing any part of the time of a man who can get eight or ten shillings a day by his skill in tempering needles, in turning a wheel, which can be done for six pence a day; and we equally avoid the loss arising from the employment of an accomplished mathematician in performing the lowest processes of arithmetic.

193. The *division of labor* cannot be successfully practised, unless there exists a great demand for its produce; and it requires larger capital to be employed in those arts in which it is used. In watch-making it has been carried, perhaps, to the greatest extent. In an examination before a Committee of the House of Commons, it was stated that there are a hundred and two distinct branches of this art, to each of which a boy may be put apprentice; and that he only learns his master's department, and is unable, after his apprenticeship has expired, without subsequent instruction, to work at any other branch. The watch-finisher, whose business it is to put together the scattered parts, is the only one, out of the hundred and two persons, who can work in any other department than his own.

ON THE SEPARATE COST OF EACH PROCESS IN A MANUFACTURE.

194. The great competition introduced by machinery, and the application of the principle of the subdivision of labor, render it continually necessary for each producer to be on the watch, to discover improved methods by which the cost of the article he manufactures may be reduced; and, with this view, it is of great importance to know the precise expense of every process, as well as of the wear and tear of machinery which is due to it. The same information is desirable for others, through whose hands the manufactured goods are distributed; because it enables them to give reasonable answers or explanations to the objections of inquirers, and also affords them a better chance of suggesting to the manufacturer changes in the fashion of his goods, which may be more suitable either to the tastes or to the finances of his customers. To the statesman such knowledge is still more important, as without it he must trust entirely to others, and can form no judgment, worthy of confidence, of the effect any tax may produce, or of the injury the manufacturer or the country may suffer by its imposition.

195. One of the first advantages which suggests itself as likely to arise from a correct analysis of the expense of the several processes of any manufacture, is the indication which it furnishes of the course in which improvement should be directed. If any method should be contrived of diminishing by one-fourth the time required for fixing on the heads of the pins, the expense of making them would be reduced about thirteen per cent., whilst a reduction of one half the time employed in spinning the coil of wire out of which the heads are cut, would scarcely make any sensible difference in the cost of the manufacture of the whole article. It is, therefore, obvious, that the attention would be much more advantageously directed to shortening the former than the latter process.

196. The expense of manufacturing, in a country where the machinery is of the rudest kind, and manual labor is very cheap, is curiously exhibited in the price of cotton cloth in the island of Java. The cotton, in the seed, is sold by the picul, which is a weight of about 133 lbs. Not above one-fourth or one-fifth of this weight, however, is cotton; and the natives, by means of rude wooden rollers, separate, at the expense of one day's labor, about 1¼ lb. of cotton from the seed. In this stage it is worth between four and five times its original cost: and the prices of the same substance, in its different stages of manufacture, are, for one picul: Cotton in the seed, 2 to 3 dollars—Clean cotton, 10 to 11—Cotton thread, 24—Cotton thread, dyed blue, 35—Good ordinary cotton cloth, 50.

Thus it appears that the expense of spinning in Java is 117 per cent. on the value of the raw material; that the expense of dying thread blue is 45 per cent. on its value; and that the expense of weaving cotton thread into cloth is 117 per cent. on its value. The expense of spinning cotton into a fine thread is, in England, about 33 per cent.*

197. As an example of the cost of the different processes of a manufacture, perhaps an analytical statement of the expense of the volume now in the reader's hands† may not be uninteresting, more especially as it will afford an insight into the nature and extent of the taxes upon literature. It is found economical to print it upon paper of an unusually large size, so that although thirty-two pages are really contained in each sheet, this work is still called 8vo.

	£	s.	d.
To printer for composing (per sheet of 32 pages) 3*l*. 1*s*., 10½ sheets,	£32	0	6
To printer for composing small type, as in extracts and contents, extra per sheet, 3*s*. 10*d*. - - -	2	0	3
To printer for composing table-work, extra per sheet, 5*s*. 6*d*. - -	2	17	9
Average charge for corrections per sheet, 3*l*. 2*s*. 10*d*. - - -	33	0	0
Press-work, 3,000 being printed off, per sheet, 3*l*. 10*s*. - - -	36	15	0

* These facts are taken from Crawfurd's Indian Archipelago.

† This refers to the London edition, as published by Chas. Knight.

Paper for 3,000, at 1*l.* 11*s.* 6*d.* per ream, weighing 28 lbs.: the duty on paper at 3*d.* per lb. amounts to 7*s.* per ream, so that the 63 reams which are required for the work will cost: Paper, 77*l.* 3*s.* 6*d.*—Excise Duty, 22*l.* 1*s.*, - - -	99	4	6
Total expense of printing and paper,	205	18	0
Steel plate for title page, £0 7 6			
Engraving on steel, letters 1 1 0			
Ditto Head of Bacon, - 2 2 0			
Total expense of title page,	3	10	6
Printing title page, at 6*s.* per 100,	9	0	0
Paper for ditto, at 1*s.* 9*d.* per 100,	2	12	6
Expenses of advertising, - -	40	0	0
Sundries, - - - - - - -	5	0	0
Total expense in sheets, - -	266	1	0
Cost of a single copy in sheets, -	0	1	9¼
Extra boarding, - - - - -	0	0	6
Cost of each copy, boarded, -	0	2	3¼

198. This analysis requires some explanation. The printer usually charges for composition by the sheet, supposing the type to be all of one kind; and as this charge is regulated by the size of the letter, on which the quantity of it in a sheet depends, little dispute can arise after the price is agreed upon. If there are a few extracts, or other parts of the work, which require to be printed in smaller type, or if there are many notes, or several passages in Greek, or in other languages, requiring a different type, these are considered in the original contract, and a small additional price per sheet allowed. If there is a larger portion of small type, it is better to have a specific additional charge for it per sheet. If any work, with irregular lines, and many figures, and what the printers call rules, occurs, it is called table-work, and is charged at an advanced price per sheet. Examples of this are frequent in the present volume. If the page consists entirely of figures, as in mathematical tables, which require very careful correction, the charge for composition is usually doubled. A few years ago I printed a table of logarithms, on a large sized page, which required great additional labor and care from the readers, in rendering the proofs correct, for which several new types were cast, although new punches were not required, and for which stereotype plates were cast, costing about 2*l.* per sheet. In this case 11*l.* per sheet were charged, although ordinary composition, with the same sized letter, in demy octavo, could have been executed at thirty-eight shillings per sheet: but as the expense was ascertained before commencing the work, it gave rise to no difficulties.

199. The charge for *corrections* and *alterations* is one which, from the difficulty of measuring it, gives rise to the greatest inconvenience, and is as disagreeable to the publisher, (if he be the agent between the author and the printer,) and the master printer or his foreman, as it is to the author himself. If the author study economy, he should make the whole of his corrections in the manuscript, and should copy it out fairly: it will then be printed correctly, and he will have little to pay for corrections. But it is scarcely possible to judge of the effect of any passage correctly, without having it set up in type; and there are few subjects to which an author does not find he can add some details or explanations, when he sees his views in print. If, therefore, he wish to save his own labor in transcribing, and to give the last polish to the language, he may accomplish these objects at an increased expense. If the printer possess a sufficient stock of type, it will contribute still more to the convenience of the author to have his whole work put up in what are technically called *slips*,* and then to make all the corrections, and to have as few revises as he can. The present work was set up in slips, but the corrections were unusually large, and the revises frequent.

200. The press-work, or *printing off*, is charged at a price agreed upon for each two hundred and fifty sheets; any broken number is still considered as two hundred and fifty. When a large edition is required, the price for two hundred and fifty is reduced; thus, in the present volume, two hundred and fifty copies, if printed alone, would have been charged eleven shillings per sheet. The principle of this mode of charging is good, as it obviates all disputes; but it is to be regretted that the custom of charging for any small number the same price as for two hundred and fifty is so pertinaciously adhered to, that the master printers cannot get their men to agree to any other terms when only twenty or thirty copies are required, or even when only three or four are wanted for the sake of some experiment. Perhaps if all numbers above fifty were charged as two hundred and fifty, and all below as for half two hundred and fifty, both parties would derive an advantage.

201. The effect of the excise duty is to render the paper thin, in order that it may weigh little; but this is counteracted by the desire of the author to make his book look as thick as possible, in order that he may charge the public as much as he decently can; and so on that ground alone it is of no importance. There is, however, another effect of this duty, which both the public and the author feel; for they pay, not merely the duty which is charged, but also the profit on that duty, which the paper-maker requires for the use of additional capital; and also the profit to the publisher and bookseller on the increased price of the volume.

202. The estimated charge for advertisements is, in the present case, about the usual allowance for such a volume; and, as it is considered that advertisements in newspapers are the most ef-

* Slips are long pieces of paper, on which sufficient matter is printed to form, when divided, from two to four pages of text.

fectual, where the smallest pays a duty of 3*s*. 6*d*., nearly one half the charge of advertising is a tax.

203. It appears, then, that upon an expenditure of 276*l*. on the present volume, 42*l*. are paid in the shape of a direct tax. Whether the profits arising from such a mode of manufacturing will justify such a rate of taxation, can only be estimated when the returns from the volume are considered, a subject that will be discussed in our subsequent pages. It is at present sufficient to observe, that the tax on advertisements is an impolitic tax, when contrasted with that upon paper, and on other materials employed. The object of all advertisements is, by making known articles for sale, to procure for them a better price, if the sale is to be by auction; or a larger extent of sale, if by retail dealers. Now the more any article is known, the more quickly it is discovered whether it contributes to the comfort or advantage of the public, and the more quickly its consumption is assured if it is found valuable. It would appear, then, that every tax on communicating information respecting articles which are the subject of taxation in another shape, is one which must considerably reduce the amount that would have been raised had no impediment been placed in the way of making known to the public their qualities and their price.

ON THE CAUSES AND CONSEQUENCES OF LARGE FACTORIES.

204. On examining the analysis which has been previously given of the operations in the art of pin-making, it will be observed, that ten individuals are employed in it, and also that the time occupied in executing the several processes is very different. In order, however, to render more simple the reasoning which follows, it will be convenient to suppose that each of the six processes there described requires an equal quantity of time. This being supposed, it is at once apparent, that, to conduct an establishment for pin-making most profitably, the number of persons employed must be a multiple of ten. For if a person with small means has only sufficient capital to enable him to employ half that number of persons, they cannot each of them constantly adhere to the execution of the process; and if a manufacturer employs any number not a multiple of ten, a similar result must ensue with respect to some portion of them. The same reasoning extends to all manufactories which are conducted upon the principle of the *division of labor*, and we arrive at this general conclusion—

When (from the peculiar nature of the produce of each manufactory) the number of processes into which it is most advantageous to divide it is ascertained, as well as the number of individuals to be employed, then all other manufactories which do not employ a direct multiple of this number, will produce the article at a greater cost. This principle ought always to be kept in view in great establishments, although it is quite impossible, even with the best system of the *division of labor*, to carry it rigidly into execution. The proportion of the persons employed who possess the greatest skill is, of course, to be first attended to. That exact ratio which is most profitable for a factory employing a hundred workmen, may not be quite the most fit for one in which there are five hundred; and probably both admit of variations in their arrangements without materially increasing the cost of their produce. But it is quite certain that no individual, nor in the case of pin-making could any five individuals, ever hope to compete with an extensive establishment. Hence arises one of the causes of the great size of manufacturing establishments, which have increased with the progress of civilization. Other circumstances, however, contribute to the same end, and arise also from the same cause—*the division of labor*.

205. The material out of which the manufactured article is produced, must, in the several stages of its progress, be conveyed from one operator to the next in succession; this can be done at least expense when they are all working in the same establishment. If the material is heavy, this reason acts with additional force; but in cases where it is light, the danger arising from frequently removing it may render it desirable to have all the processes carried on in the same building. In the cutting and polishing of glass this is the case; whilst in the art of needle-making, several of the processes are carried on in the cottages of the workmen. It is, however, clear that the latter plan, which is attended with some advantages to the family of the workmen, can be adopted only where there exists a sure and quick method of knowing that the work has been well done, and that the whole of the materials given out have been really employed.

206. The inducement to contrive machines for any process of manufacture increases with the demand for the article; and the introduction of machinery, on the other hand, tends to increase the quantity produced, and to lead to the establishment of large factories. An illustration of these principles may be found in the history of the manufacture of patent net.

The first machines for weaving this article were very expensive, costing from a thousand to twelve or thirteen hundred pounds. The possessor of one of these, though it greatly increased the quantity he could produce, was nevertheless unable, when working eight hours a day, to compete with the old methods. This arose from the large capital invested in the machinery; but he quickly perceived that, with the same expense of fixed capital and a small addition to his circulating capital, he could work the machine during the whole twenty-four hours. The profits thus realized soon induced other persons to direct their attention to the improvement of those machines; and the price was considerably reduced, at the same time that the rapidity of production of the patent net was increased. If machines be kept working through

the twenty-four hours, it will be necessary that some person shall attend to admit the workmen at the time they relieve each other; and whether the porter or other servant so employed admit one person or twenty, his rest will be equally disturbed. It will also be necessary, occasionally, to adjust or repair the machine; and this will be done much better by a workman accustomed to machine making, than by the person who uses it. Now, since the good performance and the duration of machines depend to a very great extent upon correcting, as soon as it appears, every shake or imperfection in their parts, it will soon become apparent that a workman resident on the spot will reduce the expenditure arising from the wear and tear of machinery. But in the case of a single lace-frame, or a single loom, this would be too expensive a plan. Here, then, arises another circumstance which tends to enlarge the extent of a factory. It ought to consist of such a number of machines as shall occupy the whole time of one workman in keeping them in order, and in making any casual repairs: if it is extended beyond this, the same principle of economy would point out the necessity of doubling or tripling the number of machines, in order to employ the whole time of two or three skilful workmen.

207. Where one part of each workman's labor consists in the exertion of mere physical force, as in weaving and many similar arts, it will soon occur to the manufacturer, that if the loom or lace-frame were driven by a steam-engine, the same man might attend to two or more looms at once; and since we already suppose that he already employed one or more operative engineers, he may so arrange the number of his looms that the charge of keeping them and the steam-engine in order shall just fully occupy their time. One of the first effects will be, that the steam-engine can drive the looms twice as fast as human force; and as each man, when relieved from bodily labor, can attend to two looms, it will be found that one workman can now make as much cloth as four could do before. This increase was, however, greater than that which really took place at first; for the limit of the velocity of the parts of the loom depended upon the strength of the thread, and the quickness with which it commenced its motion: but an improvement was soon made, by which the motion commenced slowly, and gradually acquired greater velocity than it was safe to give it at once. This improvement increased the speed from 100 to about 120 strokes per minute.

208. Pursuing the same principles, the manufactory becomes gradually so enlarged, that the expense of lighting during the night amounts to a considerable sum; and as there are already attached to the establishment persons who are up all night, and can, therefore, constantly attend to it, and also engineers to make and keep in repair any machinery, the addition of an apparatus for making gas to light the factory introduces a new extension, at the same time that it contributes, by diminishing the expense of lighting, and the risk of accidents by fire, to reduce the cost of manufacturing.

209. Long before a factory has reached this extent, it will have been found necessary to establish an accountant's department, with clerks to pay the workmen, and to see that they arrive at their stated times; and this department must be in communication with the agents who purchase the raw produce, and with those who sell the manufactured article.

210. It would be of great importance, if, in every large establishment, the modes of paying the different persons employed could be so arranged, that each should derive advantage from the success of the whole, and that the profits of the individuals should advance as the factory itself produced profit, without the necessity of making any change in the wages agreed upon. This is by no means easy to effect, particularly amongst that class whose daily labor procures for them their daily meal. The system which has long been pursued in working the Cornish mines, although not exactly fulfilling these conditions, yet possesses advantages which make it worthy of attention, as having considerably approached towards them, and as tending to render fully effective the faculties of all engaged in it.

211. In the mines of Cornwall, almost the whole of the operations both above and below ground are contracted for. The manner of making the contract is nearly as follows. At the end of every two months, the *work* which it is proposed to carry on during the next period is marked out. It is of three kinds. 1. *Tut-work*, which consists in sinking shafts, driving levels, and making excavations; this is paid for by the fathom in depth, or in length, or by the cubic fathom. 2. *Tribute*, which is payment for raising and dressing the ore, by means of a certain part of its value when merchantable. It is this species of payment which produces such admirable effects. The miners, who are to be paid in proportion to the richness of the vein, and the quantity of metal actually extracted from it, naturally become quick-sighted in the discovery of ore, and in estimating its value; and it is their interest to avail themselves of every improvement that can bring it more cheaply to market. 3. *Dressing:* The tributors, who dig and dress the ore, can seldom afford to dress the coarsest parts of that which they raise at their contract price; they, therefore, leave it, and this portion is again let out to persons who agree to dress it at an advanced price. The lots of ore to be dressed, and the works to be carried on, having been marked out for some days, and having been examined by the men, a kind of auction is kept by the captains of the mine, in which each lot is put up, and bid for by different gangs of men. The work is then offered, at a price usually below that bid at the auction, to the lowest bidder, who rarely declines it at the rate proposed. The tribute is a certain sum out of every

twenty shillings' worth of ore raised, and may vary from three pence in the pound to fourteen or fifteen shillings. The rate of earnings in tribute is very uncertain: if a vein, which was poor when taken, becomes rich, the men earn money rapidly; and instances have occurred in which each miner of a gang has earned a hundred pounds in two months. These extraordinary cases are, perhaps, of more advantage to the owners of the mine than even to the men; for whilst the skill and industry of the workmen are greatly stimulated, the owner himself always derives greater advantage from the improvement of the vein.* This system has been introduced, by Mr. Taylor, into the lead miles of Flintshire, into those at Skipton, in Yorkshire, and into some of the copper mines of Cumberland; and it is desirable that it should become general, because no other mode of payment affords to the workmen a measure of success so directly proportioned to the industry, the integrity, and the talent, which they exert.

212. We have seen that the application of the *division of labor* tends to produce cheaper articles: it thus increases the demand, and gradually, by the effect of competition, or the hope of increased gain, causes large capitals to be embarked in extensive factories. Let us now examine the influence of such accumulation of capital directed to one object. In the first place it enables the most important principle on which the *division of labor* rests, to be carried almost to its extreme limits: not merely the precise amount of skill is purchased which is necessary for the execution of each process, but throughout every stage from that in which the raw material is procured, to that by which the finished produce is conveyed into the hands of the consumer, the same economy of skill prevails. The quantity of work produced by a given number of people is greatly augmented by such an extended arrangement; and the result is necessarily a great reduction in the cost of the article which is brought to market.

213. Amongst the causes which tend to the cheap production of any article, and which require additional capital, may be mentioned the care which is taken to allow no part of the raw produce, out of which it is formed, to be absolutely wasted. An attention to this circumstance sometimes causes the union of two trades in one factory, which otherwise would naturally have been separated. An enumeration of the arts to which the horns of cattle are applicable, furnishes a striking example of this kind of economy. The tanner, who has purchased the hides, separates the horns, and sells them to the makers of combs and lanterns. The horn consists of two parts, an outward horny case, and an inward conical-shaped substance, somewhat intermediate between indurated hair and bone. The first process consists in separating these two parts, by means of a blow against a block of wood. The horny exterior is then cut into three portions by means of a frame-saw.

1. The lowest of these, next the root of the horn, after undergoing several processes, by which it is rendered flat, is made into combs.

2. The middle of the horn, after being flattened by heat, and its transparency improved by oil, is split into thin layers, and forms a substitute for glass in lanterns of the commonest kind.

3. The tip of the horn is used by the makers of knife-handles and of the tops of whips, and for other similar purposes.

4. The interior, or core of the horn, is boiled down in water. A large quantity of fat rises to the surface; this is put aside, and sold to the makers of yellow soap.

5. The liquid itself is used as a kind of glue, and is purchased by the cloth-dressers for stiffening.

6. The bony substance, which remains behind, is then sent to the mill, and, being ground down, is sold to the farmers for manure.

Besides these various purposes to which the different parts of the horn are applied, the clippings, which arise in comb-making, are sold to the farmer for manure at about one shilling a bushel. In the first year after they are spread over the soil they have comparatively little effect, but during the next four or five their efficacy is considerable. The shavings which form the refuse of the lantern-maker are of a much thinner texture: a few of them are cut into various figures and painted, and used as toys, for, being hygrometic, they curl up when placed in the palm of a warm hand. But the greater part of these shavings are sold also for manure, which, from their extremely thin and divided form, produces its full effect upon the first crop.

214. Another event which has arisen, in one trade at least, from the employment of large capital, is, that a class of middle-men, who were formerly interposed between the maker and the merchant, now no longer exist. Formerly, when calico was woven in the cottages of the workmen, there existed a class of persons who travelled about and purchased the pieces so made, in large numbers, for the purpose of selling them to the exporting merchant. But the middle-man was obliged to examine each piece, in order to know that it was perfect, and of full measure. Now, although the greater part of the workmen might be depended upon, yet the fraud of the few would render this examination indispensable: for the value of character, though great in all circumstances of life, can never be so fully experienced by persons possessed of small capital, as by those employing much larger sums. Any single cottager, if he were detected by one purchaser, might hope that the fact would not become known to all the rest; whilst the larger the sums of money for which any merchant deals, the more is his character for punctuality studied and known by others. Thus it happens that high charac-

* For a detailed account of the method of working the Cornish mines, see a paper of Mr. John Taylor's, 'Transactions of the Geological Society,' vol. ii. p. 309.

ter supplies the place of an additional portion of capital; and the merchant, in dealing with the great manufacturer, is saved from the expense of verification, by knowing that the loss, or even the impeachment, of the manufacturer's character, would be attended with greater pecuniary detriment to himself than any profit upon any single transaction could compensate.

215. To such an extent is this confidence in character carried, that, at one of our largest towns, sales and purchases on a very extensive scale are made daily in the course of business without any of the parties ever exchanging a written document. The amount of well-grounded confidence, which such a practice indicates, is one of the many advantages an old manufacturing country always possesses over its rivals.

216. A breach of confidence of this kind, which might have been attended with very serious embarrassment, occurred in the recent expedition to the mouth of the Niger.

"We brought with us from England," Mr. Lander states, "nearly a hundred thousand needles of various sizes, and amongst them was a great quantity of '*Whitechapel Sharps*,' warranted '*superfine, and not to cut in the eye.*' Thus highly recommended, we imagined that these needles must have been excellent indeed; but what was our surprise, some time ago, when a number of them which we had disposed of were returned to us, with a complaint that they were all eyeless, thus redeeming with a vengeance the pledge of the manufacturer, 'that they would not cut in the eye.' On an examination afterwards, we found the same fault with the remainder of the 'Whitechapel Sharps,' so that to save our credit we have been obliged to throw them away."*

217. The influence of established character in producing confidence operated in a very remarkable manner at the time of the exclusion of British manufactures from the Continent during the last war. One of our largest establishments had been in the habit of doing extensive business with a house in the centre of Germany; but, on the closing of the continental ports against our manufactures, heavy penalties were inflicted on all those who contravened the Berlin and Milan decrees. The English manufacturer continued, nevertheless, to receive orders, with directions how to consign them, and appointments for the time and mode of payment, in letters, the handwriting of which was known to him, but which were never signed, except by the Christian name of one of the firm, and even in some instances they were without any signature at all. These orders were executed; and in no instance was there the least irregularity in the payments.

218. Another circumstance may be noticed, which to a small extent is more advantageous to large than small factories. In the export of several articles of manufacture, a drawback is allowed by government, of a portion of the duty paid on the importation of the raw material. In such circumstances, certain forms must be gone through in order to protect the revenue from fraud; and a clerk, or one of the partners, must attend at the custom-house. If the quantity exported is inconsiderable, the small manufacturer frequently does not find the drawback will repay him for his loss of time; whilst the agent of the large establishment occupies nearly the same time in receiving a drawback of several thousands, as the smaller exporter does of a few shillings.

219. In many of the large establishments of our manufacturing districts, substances are employed which are the produce of remote countries, and which are, in several instances, almost peculiar to a few situations. The discovery of any new locality, where such articles exist in abundance, is a matter of great importance to any establishment consuming them largely; and it has been found, in some instances, that the expense of sending persons to great distances, purposely to discover and to collect such produce, has been amply repaid. Thus it has happened that the snowy mountains of Sweden and Norway, as well as the warmer hills of Corsica, have been almost stripped of one of their vegetable productions, by agents sent expressly from one of our largest establishments, for the dying of calicoes. It is owing to the same command of capital, and to the scale on which the operations of a large factory are carried, that their returns will admit of the expense of sending out agents to examine into the wants and tastes of distant countries, as well as of trying experiments, which, although profitable to them, would be ruinous to smaller establishments possessing more limited resources.

These opinions have been so fully expressed in the Report of the Committee of the House of Commons on the Woollen Trade, in 1806, that we shall close this chapter with an extract, in which the advantages of great factories are summed up.

"Your Committee have the satisfaction of seeing that the apprehensions entertained of factories are not only vicious in principle, but they are practically erroneous; to such a degree, that even the very opposite principles might be reasonably entertained. Nor would it be difficult to prove that the factories, to a certain extent at least, and in the present day, seem absolutely necessary to the well-being of the domestic system; supplying those very particulars wherein the domestic system must be acknowledged to be inherently defective; for it is obvious, that the little master manufacturers cannot afford, like the man who possesses considerable capital, to try the experiments which are requisite, and incur the risks, and even losses, which almost always occur, in inventing and perfecting new articles of manufacture, or in carrying to a state of greater perfection articles already established.

* Lander's Journal of an Expedition to the Mouth of the Niger, vol. ii. p. 42.

He cannot learn, by personal inspection, the wants and habits, the arts, manufactures, and improvements, of foreign countries; diligence, economy, and prudence, are the requisites of his character, not invention, taste, and enterprize; nor would he be warranted in hazarding the loss of any part of his small capital. He walks in a sure road as long as he treads in the beaten track; but he must not deviate into the paths of speculation. The owner of a factory, on the contrary, being commonly possessed of a large capital, and having all his workmen employed under his own immediate superintendance, may make experiments, hazard speculation, invent shorter or better modes of performing old processes, may introduce new articles, and improve and perfect old ones, thus giving the range to his taste and fancy, and thereby alone enabling our manufacturers to stand the competition with their commercial rivals in other countries. Meanwhile, as well worthy of remark, (and experience abundantly warrants the assertion,) many of these new fabrics and inventions, when their success is once established, become general among the whole body of manufacturers; the domestic manufacturers themselves thus benefitting, in the end, from those very factories which had been at first the objects of their jealousy. The history of almost all our other manufactures, in which great improvements have been made of late years, in some cases at an immense expense, and after numbers of unsuccessful experiments, strikingly illustrates and enforces the above remarks. It is besides an acknowledged fact, that the owners of factories are often amongst the most extensive purchasers at the halls, where they buy from the domestic clothier the established articles of manufacture, or are able at once to answer a great and sudden order; while, at home, and under their own superintendance, they make their fancy goods, and any articles of a newer, more costly, or more delicate quality, to which they are enabled by the domestic system to apply a much larger proportion of their capital. Thus, the two systems, instead of rivalling, are mutual aids to each other; each supplying the other's defects, and promoting the other's prosperity."

ON THE POSITION OF LARGE FACTORIES.

220. It is found in every country, that the situation of large manufacturing establishments is confined to particular districts. In the earlier history of a manufacturing community, before cheap modes of transport have been extensively introduced, it will almost always be found that the article will be manufactured near those spots in which nature has produced the raw material. In the heavier articles, and in those the value of which depends more upon the material than the labor expended on it, this will most frequently be the case. Most of the metallic ores being exceedingly heavy, and being mixed up with large quantities of weighty and useless materials, must be smelted at no great distance from the spot which affords them: fuel and power are the requisites for reducing them; and any considerable fall of water in the vicinity will naturally be resorted to for aid in all the coarser exertions of physical force—for pounding the ore, blowing the furnaces, or for hammering and rolling out the iron. There are indeed peculiar circumstances which will modify this. Iron, coal, and limestone, frequently occur in the same district; but the union of the fuel in the same locality with the ore does not happen with respect to other metals. In Cornwall there exist mines of copper and of tin, but none of coal. The copper ore, which requires the largest quantity of fuel for its reduction, is conveyed by ships to the coal fields of Wales, and is smelted at Swansea; whilst the vessels which convey it, take back cargoes of coal to supply the steam-engines for draining the mines and to smelt the tins, which require, for that purpose, a much less quantity of fuel than copper.

221. Rivers, passing through districts rich in coal and metals, will form the first high roads for the conveyance of weighty produce to stations in which other conveniences present themselves for the farther application of human skill. Canals will succeed, or lend their aid to these; and the yet unexhausted application of steam and gas holds out a hope of attaining almost the same advantages for countries to which nature seemed for ever to have denied them. Manufactures, commerce, and civilization, ever follow the line of new and cheap communications. Twenty years ago, the Mississippi poured the vast volume of its waters in lavish profusion through thousands of miles of countries, which scarcely supported a few wandering and uncivilized tribes of Indians. The power of the stream seemed to set at defiance the efforts of man to ascend its course; and, as if to render the task still more hopeless, large trees, torn from the surrounding forests, were planted in its bottom, forming in some places barriers, in others the nucleus of banks, and accumulating in the same spot, which but for accident would have been free from either, the difficulties and dangers of sand-banks and of rocks. Four months of incessant toil could scarcely convey a small bark with its worn-out crew two thousand miles up this stream. The same voyage is now performed by large vessels impelled by steam, carrying hundreds of passengers, enjoying all the comforts and luxuries of civilized life, in the short period of fifteen days. Instead of the hut of the Indian—and the far more unfrequent log-house of the thinly scattered settlers—villages, towns, and cities, have arisen on its banks; and the same engine, which stemmed the force of these powerful waters, will probably tear from their bottom the obstructions which have hitherto impeded and rendered dangerous their navigation.*

* The amount of obstructions arising from the casual fixing of trees in the bottom of the river, may be estimated from the proportion of steamboats destroyed by running upon them. The subjoined statement is taken from the American Almanac for

222. The accumulation of many large manufacturing establishments in the same district has a tendency to bring together purchasers or their agents from great distances, and thus to cause the institution of a public mart or exchange. This contributes to increase the information relative to the supply of raw material, and the state of demand for their produce, with which it is necessary manufacturers should be well acquainted. The very circumstance of collecting periodically, at one place, as large a number as possible, both of those who supply the market and those who require its produce, tends strongly to check those accidental fluctuations to which a small market is ever subject, as well as to render the average of the prices paid much more uniform in its course.

223. When capital has been invested in machinery, and in building for its accommodation, and when the inhabitants of the neighborhood have acquired a knowledge of the modes of working at it, reasons of considerable weight are required to cause its removal. Such changes of disposition do, however, occur; and they have been alluded to by the Committee on the Fluctuation of Manufacturers' Employment, as one of the sources interfering most materially with a uniform rate of wages: it is, therefore, of particular importance to the workmen to be acquainted with the real causes which have driven manufactures from their ancient seats.

"The migration or change of place of any manufacturer has sometimes arisen from improvements of machinery not applicable to the spot where such manufacture was carried on, as appears to have been the case with the woollen manufacture, which has, in great measure, migrated from Essex, Suffolk, and other southern counties, to the northern districts, where coal, for the use of the steam-engine, is much cheaper. But this change has, in some instances, been caused or accelerated by the conduct of the workmen, in refusing a reasonable deduction of wages, or opposing the introduction of some kind of improved machinery or process; so that, during the dispute, another spot has, in great measure, supplied their place in the market. *Any violence used by the workmen against the property of their masters, and any unreasonable combination on their part, is almost sure thus to be injurious to themselves.*"*

224. These removals become of serious consequence when the factories have been long established, because a population commensurate with their wants invariably grows up around them. The combinations in Nottinghamshire, of persons under the name of Ludd-ites, drove a great number of lace-frames from that district, and caused establishments to be formed in Devonshire. We ought also to observe, that the result of driving any establishment into a new district, where similar ones have not previously existed, is not merely to place it out of the reach of such combinations, but, after a few years, the example of its success will most probably induce other capitalists in the new district to engage in the same manufacture: and thus, although only one establishment should be driven away, the workmen, through whose combination its removal was effected, will not merely suffer by the withdrawing of that portion of demand for their labor which the factory caused, but the value of that labor itself will be reduced by the competition of a new field of production.

225. Another circumstance, which has its influence on this question, is the nature of the machinery. Heavy machinery, such as stamping-mills, steam-engines, &c., cannot readily be moved, and must always be taken to pieces for that purpose; but where the machinery of a factory consists of a multitude of separate machines, each complete in itself, and all put in motion by one source of power, such as a water-wheel or a steam-engine, then the removal is much less inconvenient. Thus, stocking-frames, lace-machines, and looms, might, with but a small separation of their parts, be transported to more favorable positions.

226. It is of great importance that the more intelligent amongst the class of workmen should examine into the correctness of these views; because, without having their attention directed to them, the whole class may, in some instances, be led by designing persons to pursue a course, which, although apparently plausible, is in reality directly at variance with their own best interests. I confess I am not without a hope that this volume may fall into the hands of workmen, perhaps better qualified than myself to reason upon a subject which requires only plain common sense, and whose powers are sharpened by its importance to their personal happiness. In asking their attention to the preceding remarks, and to those which I shall offer respecting combinations, I can claim only one advantage over them, namely: that I never have had, and in all human probability never shall have, the slightest pecuniary interest, to influence even remotely, or by anticipation, the judgments I have formed on the facts which have come before me.

ON OVER-MANUFACTURING.

227. One of the natural and almost inevitable consequences of competition is the production of a supply far larger than the demand requires. This usually arises periodically; and it is equally important, both to the masters and to the workmen, to prevent its occurrence, or to foresee its arrival. In situations where a great number of very small capitalists exists—where

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1832: "Between the years 1811 and 1831, three hundred and forty-eight steamboats were built on the Mississippi and its tributary streams. During that period a hundred and fifty were lost or worn out. Of the hundred and fifty lost or worn out were, 63 worn out; 36 lost by snags; 14 burnt; 3 lost by collision: 34 by accidents not ascertained."—Thirty-six, or nearly one fourth, being destroyod by accidental obstructions!

* This passage is not printed in Italics in the original; but it has been thus marked in the above extract, from its importance, and from the conviction that the most extended discussion will afford additional evidence of its truth.

each master himself works and is assisted by his own family, or by a few journeymen—and where a variety of different articles are produced—a curious system of compensation has arisen, which, in some measure, diminishes the extent to which fluctuations of wages would otherwise reach. This is accomplished by a species of middle-men or factors, persons possessing greater or less capital, who, whenever the price of any of the articles in which they deal is greatly reduced, purchase it at a low price on their own account, in the hopes of selling it at a profit when the market for it is better. These persons, in ordinary times, act as salesmen or agents, and make up assortments of goods at the market price, for the use of the home or foreign dealer. They possess large warehouses, in which to make up their orders, or keep in store articles purchased during periods of depression: thus acting as a kind of fly-wheel in equalizing the market price.

228. In the greater establishments, the effect of over-manufacturing is different. When an over-supply has reduced prices, one of two events usually occurs: the first is a diminished payment for wages; the other is a diminution of the number of hours during which the laborers work, together with a diminished rate of wages. In the former case production continues to go on at its ordinary rate: in the latter, the production itself being checked, the supply again adjusts itself to the demand as soon as the stock on hand is worked off, and prices then regain their former level. The latter course appears, in the first instance, to be the best both for masters and men; but there seems to be a difficulty in accomplishing this, except where the trade is in few hands. In fact, it seems to be necessary, for its success, that there should be a combination amongst the masters or amongst the men; or, what is always far preferable to either, a mutual agreement for their joint interests. But a combination among the men is difficult, and is always attended with the evils arising from the ill-will which exists against any who, in the perfectly justifiable exercise of their judgment, are disposed not to act with the majority. The combination of the masters is on the other hand unavailing, unless the whole body of them agree: for if any one master can procure more labor for his money than the rest, he must be able to undersell them.

229. If we look only at the interests of the consumer, the case is different. When too large a supply has produced a great reduction of price, it has opened the consumption of the article to a new class, and has increased the consumption of those who previously employed it: it is, therefore, against the interest of both these parties that a return to the former price should occur. It is also certain, that by the diminution of profit which the manufacturer suffers from the diminished price, his ingenuity will be additionally stimulated; and that he will apply himself to discover other and cheaper sources for the supply of his raw material—to contrive improved machinery, which shall manufacture it at a cheaper rate—or to introduce new arrangements into his factory, which shall render the superintendance of it more perfect. In the event of his success by any of these courses, or by their joint effects, a real and substantial good will be effected. A larger portion of the public will receive advantage from the use of the article, and they will procure it at a lower price; and the manufacturer, although his profit per cent. on each operation is reduced, will yet, by the more frequent returns on the larger produce of his factory, find his real gain per cent., at the end of the year, nearly the same as it was before; whilst the wages of the workman will return to their level, and both the manufacturer and the workman will find the fluctuations of demand less considerable, from being dependent on a larger number of customers.

230. It would be highly interesting, if we could trace, even approximate, through the history of any great manufacture, the effects of gluts in producing improvements in machinery, or in methods of working; and if we could show what addition, to the annual quantity of goods previously manufactured, was produced by each alteration. It would probably be found, that the increased quantity manufactured by the same capital, when worked with the new improvement, would produce nearly the same rate of profit as other modes of investment.

231. Supposing new and cheaper modes of producing not to be discovered, and that the production continues to exceed the demand, then it is apparent that too much capital is employed in the trade; and after a time, the diminished rate of profit will drive some of the manufacturers to other occupations. What particular individuals will leave it, must depend on a variety of circumstances. Superior industry and attention will enable some factories to make a profit rather beyond the rest; superior capital in others will enable them, without these advantages, to support competition longer, even at a loss, with the hope of driving the smaller capitalists out of the market, and then re-imbursing themselves by an advanced price. It is, however, better for all parties, that this contest should not last long; and it is important, that no artificial restraint should interfere to prevent it. An instance of such restriction and of its injurious effect occurs at the port of Newcastle, where a particular act of Parliament requires that every ship shall be loaded in its turn. The Committee of the House of Commons, in their Report on the Coal Trade, state that, "Under the regulations contained in this act, if more ships enter into the trade than can be profitably employed in it, the loss produced by detention in port, and waiting for a cargo, which must consequently take place, instead of falling, as it naturally would, upon particular ships, and forcing them from the trade, is now divided

evenly amongst them; and the loss thus created is shared by the whole number."—*Report*, p. 6.

232. It is not pretended, in this short view, to trace out all the effects or remedies of over-manufacturing; it is a difficult subject, and, unlike some of the questions already treated, requires a very extensive combination of the relative influence of many causes.

INQUIRIES PREVIOUS TO COMMENCING ANY MANUFACTORY.

233. There are many inquiries which ought always to be made previous to the commencement of the manufacture of any new article. These chiefly relate to the expense of tools, machinery, raw materials, and all the outgoings necessary for its production,—to the extent of the demand which is likely to arise,—to the time in which the circulating capital will be replaced,—and to the quickness or slowness with which the new article will supercede those already in use.

234. The expense of tools and of new machines will be more difficult to ascertain, in proportion as they differ from those already employed; but the variety in constant use in our various manufactories is such, that few inventions now occur in which some considerable portion may not be found resembling others already constructed. The cost of the raw material is usually less difficult to determine, but there occasionally arise cases in which it becomes important to examine whether the supply, at the given price, can be depended upon: for in the case of a small consumption, the additional demand arising from a factory may produce a considerable temporary rise in price, although the same circumstance may ultimately reduce its price.

235. The quantity of any new article likely to be consumed is a most important subject for the consideration of the projector of a new manufacture. As these pages are not intended for the instruction of the manufacturer, but rather for the purpose of giving a general view of the subject, an illustration of the way in which such questions are regarded by practical men, will, perhaps, be most instructive. The following extract from the evidence given before a Committee of the House of Commons, in the Report on Artizans and Machinery, shows the extent to which articles, apparently the most insignificant, are consumed, and the view which the manufacturer takes of them.

The person examined on this occasion was Mr. Ostler, a manufacturer of glass beads and other toys of the same substance, from Birmingham. Several of the articles made by him were placed upon the table, for the inspection of the Committee of the House of Commons, which held its meetings in one of the committee-rooms.

"*Question.* Is there any thing else you have to state upon this subject?

"*Answer.* Gentlemen may consider the articles on the table as extremely insignificant; but perhaps I may surprise them a little by mentioning the following fact. Eighteen years ago, on my first journey to London, a respectable looking man in the city asked me if I could supply him with dolls' eyes, and I was foolish enough to feel half offended; I thought it derogatory to my new dignity as a manufacturer, to make dolls' eyes. He took me into a room quite as wide, and perhaps twice the length of this, and we had just room to walk between stacks from the floor to the ceiling, of parts of dolls. He said, 'these are only the legs and arms; the trunks are below.' But I saw enough to convince me, that he wanted a great many eyes; and as the article appeared quite in my own line of business, I said I would take an order by way of experiment; and he showed me several specimens. I copied the order. He ordered various quantities, and of various sizes and qualities. On returning to the Tavistock Hotel, I found that the order amounted to upwards of £500. I went into the country, and endeavored to make them. I had some of the most ingenious glass toy makers in the kingdom in my service; but when I showed it to them they shook their heads, and said they had often seen the article before, but could not make it. I engaged them by presents to use their best exertions; but after trying and wasting a great deal of time for three or four weeks, I was obliged to relinquish the attempt. Soon afterwards I engaged in another branch of business (chandelier furniture), and took no more notice of it. About eighteen months ago I resumed the trinket trade, and then determined to think of the dolls' eyes; and about eight months since, I accidentally met with a poor fellow, who had impoverished himself by drinking, and who was dying in a consumption, in a state of great want. I showed him ten sovereigns, and he said he would instruct me in the process. He was in such a state that he could not bear the effluvia of his own lamp; but though I was very conversant with the manual part of the business, and it related to things I was daily in the habit of seeing, I felt I could do nothing from his description. (I mention this to show how difficult it is to convey by description the mode of working.) He took me into his garret, where the poor fellow had economized to such a degree that he actually used the entrails and fat of poultry from Leadenhall market to save oil (the price of the article having been lately so much reduced by competition at home.) In an instant, before I had seen him make three, I felt competent to make a gross; and the difference between his mode and that of my own workmen was so trifling, that I felt the utmost astonishment.

"*Quest.* You can now make dolls' eyes?

"*Ans.* I can. As it was eighteen years ago that I received the order I have mentioned, and feeling doubtful of my own recollection, though very strong, and suspecting that it could [not] have been to the amount stated, I last night

took the present very reduced price of that article (less than half now of what it was then,) and calculating that every child in this country not using a doll till two years old, and throwing it aside at seven, and having a new one annually, I satisfied myself that the eyes alone would produce a circulation of a great many thousand pounds. I mention this merely to show the importance of trifles, and to assign one reason, amongst many, for my conviction, that nothing but personal communication can enable our manufactures to be transplanted."

236. In many instances it appears to be exceedingly difficult to estimate the sale of an article, or the effects of a machine: a case, however, occurred in a recent inquiry, which, although not quite appropriate as an illustration of probable demand, is highly instructive as a guide in such inquiries. A committee of the House of Commons was appointed to inquire into the tolls proper to be placed on steam carriages; a question, apparently, of difficult solution, and one on which widely different opinions had been formed, if we may judge by the very different rate of tolls imposed upon such carriages by different "turnpike trusts." The principles on which the committee conducted the inquiry were these: They first endeavored to ascertain, from competent persons, the effect of the atmosphere alone in deteriorating a well constructed road. The next step was to determine the proportion in which the road was injured, by the effect of the horses' feet compared with that of the wheels. Mr. Macneill, the superintendant under Mr. Telford, of the Holyhead roads, was examined, and proposed to estimate the relative injury, from the comparative quantities of iron worn off, from the shoes of the horses, and from the tire of the wheels. From the data he possessed respecting the consumption of iron for the tire of the wheels, and for the shoes of the horses, of one of the Birmingham day coaches, he estimated the wear and tear of roads arising from the feet of the horses to be three times as great as that arising from the wheels. Supposing repairs amounting to one hundred pounds to be required on a road travelled over by a fast coach at the rate of ten miles an hour, and the same amount of injury to occur on another road, used only by waggons moving at the rate of three miles an hour, Mr. Macneill divides the injury in the following proportions:

	Fast Coach.	Heavy Waggon.
Injury arising from—		
Atmospheric changes	20	20
Wheels - - -	20	35.5
Horses' feet drawing	60	44.5
Total Injury	100	100

One of the results of these experiments is, that every coach which travels from London to Birmingham distributes about eleven pounds of wrought iron along the line of road between those two places. The committee agree that "The only ground on which a fair claim to toll can be made, on any public road, is to raise a fund, which, with the strictest economy, shall be just sufficient, first, to repay the expense of its original formation; secondly, to maintain it in good and sufficient repair." Supposing it also to be ascertained that the wheels of steam-carriages do no more injury to roads than other carriages of equal weight travelling with the same velocity, the committee now possessed the means of approximating to a just rate of toll for steam-carriages.

237. As connected with this subject, and as affording most valuable information upon points in which, previous to experiment, widely different opinions had been entertained, the following extract is inserted from Mr. Telford's Report on the State of the Holyhead and Liverpool Roads. The instrument employed for the comparison was invented by Mr. Macneill; and the road between London and Shrewsbury was selected for the place of experiment.

The general results when a waggon weighing 21 cwt. was used on different sorts of road are as follows:

	lbs.
1. On well made pavements, the draught is	33
2. On a broken stone surface, or old flint road - - - - - - -	65
3. On a gravel road - - - - -	147
4. On a broken stone road, on a rough pavement foundation - - -	46
5. On a broken stone surface, upon a bottoming of concrete, formed of Parker's cement and gravel - - - - -	46

The following statement relates to the force required to draw a coach weighing 18 cwt., exclusive of seven passengers, up roads of various inclinations:

Rate of inclination.	At six miles per hour.	At eight miles per hour.	At ten miles per hour.
1 in 20	268 lbs.	296 lbs.	318 lbs.
1 in 26	213	219	225
1 in 30	165	196	200
1 in 40	160	166	172
1 in 600	111	120	128

238. The time in which the goods produced by any new factory can be brought to market and the returns realized, should also be well considered, as well as the time the new article will take to supercede those already in use. If the article is consumed in using, the new produce will be much more easily introduced. Steel pens readily took the place of quills; and a new form of pen would, if it possessed any advantage, as easily supercede the present one. A new lock, however secure, and however cheap, would not so readily make its way. If less expensive than the old, it would be employed in new work: but old locks would rarely be removed to make way for it; and even if perfectly secure, its advance would be slow.

239. Another element in this question which should not be altogether omitted, is the opposition which the new manufacture may create by its real or apparent injury to other interests, and the probable extent of the influence of that

opposition. This is not always foreseen; and when anticipated, is often inaccurately estimated. On the first establishment of steamboats from London to Margate, the proprietors of the coaches running on that line of road petitioned the House of Commons against them, as likely to lead to the ruin of the coach proprietors. It was, however, found that the fear was imaginary; and in a very few years the number of coaches on that road was considerably increased, apparently through the very means which were thought to be adverse to it. The fear which is now entertained that steam-power and railroads may drive out of employment a large portion of the horses now used, is probably not less unfounded. On some particular lines such an effect may be produced; but in all probability the number of horses employed in conveying goods and passengers to the great lines of railroad, will exceed that which is at present used.

ON CONTRIVING MACHINERY.

240. The power of inventing mechanical contrivances, and of combining machinery, does not appear, if we may judge from the frequency of its occurrence, to be a difficult or a rare gift; and, amongst the vast multitude of inventions which have been produced almost daily for a series of years, a large part has failed from the imperfect nature of the first trials; whilst a still larger portion, which had escaped the mechanical difficulties, failed only because the economy of their operations was not sufficiently attended to.

The commissioners appointed to examine into the methods proposed for preventing the forgery of bank notes, state in their report, that, out of one hundred and seventy-eight projects communicated to the bank and to the commissioners, there were only twelve of superior skill, and nine which it was necessary more particularly to examine.

241. It is, however, a curious circumstance, that although the power of combining machinery is so common, yet the more beautiful combinations are exceedingly rare. Those which command our admiration equally by the perfection of their effects and the simplicity of their means, are found only amongst the happiest productions of genius.

To produce movements even of a complicated kind is not difficult. There exists a great multitude of known contrivances for all the more usual purposes, and if the exertion of moderate power is the end of the mechanism to be contrived, it is possible to construct the whole machine upon paper, and to judge of the proper strength to be given to each part as well as to the frame-work which supports it, and also of its ultimate effect, long before a single part of it has been executed. In fact, all the contrivance, and all the improvements, ought to be made in the drawings.

242. On the other hand, there are circumstances dependent upon physical or chemical properties, for which no drawings will be of any use. These are the legitimate objects of direct trials. For example: if the ultimate result of an engine is to be that it shall impress letters upon a copper-plate by means of steel punches pressed into it, all the mechanism by which the punches and the copper are to be moved at stated intervals, and brought into contact, is within the province of drawing, and the machinery may be arranged entirely upon paper. But a doubt may reasonably spring up, whether the bur that will be raised round the letter, which has been punched upon the copper, may not interfere with a proper action of the punch for the letter which is to be punched next adjacent to it. It may also be feared that the effect of punching the second letter, if it be sufficiently near to the first, might distort the form of that first figure. And if neither of these evils should arise, still the burs produced by the punching might be expected to interfere with the goodness of the impression produced by the copper-plate; and the plate itself, after having all but its edge covered with figures, might, from the unequal condensation which it must suffer in this process, change its form, so as to render it very difficult to take off impressions from it. It is impossible by any drawings to solve these difficulties, experiment alone can determine their nature. Such experiments have been made, and it is found that if the sides of the steel punch are nearly at right angles to the face of the letter, a very inconsiderable bur is produced; that at the depth which is sufficient for copper-plate printing, no distortion of the adjacent letters takes place, although those letters are placed very close to each other; that the small bur which arises may easily be scraped off; and that the copper-plate is not distorted by the condensation of the metal, and is perfectly fit to print from, after it has undergone this process.

243. The next stage in the progress of an invention, after the drawings are finished, and the preliminary experiments have been made, if any such should be requisite, is the execution of the machine itself. It can never be too strongly impressed upon the minds of those who are devising new machines, that to make the most perfect drawings of every part tends essentially both to the success of the trial and to economy in arriving at the result. The actual execution from working drawings is comparatively an easy task; provided, always, that good tools are employed, and that methods of working are adopted, in which the perfection of the part constructed depends less on the personal skill of the workmen, than upon the certainty of the methods they employ.

The causes of failure in this stage most frequently arise from errors in the preceding one; and it is sufficient merely to indicate a few of their sources. They usually arise from having neglected to take into consideration that metals are not perfectly rigid, but elastic. A steel cylinder of small diameter must not be considered

as an inflexible rod; but in order to insure its perfect action as an axis, it must be supported at proper intervals. Again, the strength and stiffness of the framing which supports the mechanism must be carefully attended to. It should always be recollected, that the addition of superfluous matter to the immoveable parts of a machine is not accompanied with the same evil that arises when the moving parts are increased in weight; since no additional momentum is thus generated.

244. The stiffness of the framing of a machine draws after it another important advantage. If the bearings of the axis (those places at which they are supported) are once placed in a straight line, they will continue so, if the framing be immoveable; whereas, if the framework changes its form, although ever so slightly, considerable friction will immediately arise. This effect is so well understood in the districts in which our spinning factories are numerous, that in estimating the expense of working a new factory, it is allowed that five per cent. on the power of the steam-engine will be saved if the building is fire-proof. This saving arises entirely from the greater strength and rigidity of a fire-proof building preventing the long shafts or axes that drive the machinery from being impeded by the friction which would arise from the slightest deviation in any of the bearings.

245. It is quite a mistaken idea to suppose that any imperfect mechanical work is good enough for a trial. If the experiment is at all worth trying, it ought to be tried with all the advantages of which the state of mechanical art admits; for an imperfect trial may cause an idea to be given up, which better workmanship might have proved to be practicable. On the other hand, when once its success has been established with good workmanship, it will be easy to ascertain that degree of perfection which is necessary for its due action.

It is partly owing to this circumstance, the *imperfections of the original trials*, and partly owing to the gradual improvement in the art of making machinery, that many inventions which have been tried, and have been given up in one state of art, have, at another period, been eminently successful. The idea of printing by means of moveable types had probably suggested itself to the imagination of many men conversant with impressions taken either from blocks or seals. We find amongst the instruments discovered in the remains of Pompeii and Herculaneum, stamps for words formed out of one piece of metal, and including several letters. The idea of separating these letters, and of recombining them into other words, for the purpose of stamping a book, could scarcely have failed to have occurred to many: but it would almost certainly have been rejected by those best versed in the mechanical arts of that time: for any workman of those days would have instantly perceived the impossibility of producing many thousand pieces of wood or metal fitting so perfectly, and ranging so uniformly, as the types or blocks of wood used in the art of printing.

The principle of the press which bears the name of Bramah was known about a century and a half before the machine, to which it gave rise, existed; but the imperfect state of mechanical art in the time of its inventor, would have effectually deterred him, if it had occurred to his mind, from attempting to apply it as an instrument for exerting force in practice.

These considerations prove the propriety of repeating, at the termination of intervals, during which the art of making machinery has undergone any great improvement, the trials of methods which may have previously failed, although they were founded upon just principles.

246. When the drawings have been properly made, and the machine has been well executed, and when the work it produces possesses all the qualities which were anticipated, still the invention may fail; that is, *it may fail of being brought into general practice*. This will most frequently arise from the circumstance of its producing its work at a greater expense than that at which it can be made by other methods.

247. Whenever the new or improved machine is intended to become the basis of a manufacture, it is essentially requisite that the whole expense attending its operations should be fully considered before its construction is undertaken. It is almost always very difficult to make this estimate of the expense; but the more complicated the mechanism, the less easy is the task; and in cases of great complexity and extent of machinery, it is almost impossible. It has been estimated roughly, that the expense of making the first individual of any newly invented machine will cost about five times as much as the construction of the second; an estimate which is, perhaps, sufficiently near the truth. If the second machine is to be precisely like the first, the same drawings and the same patterns will answer for it; but if, as usually happens, some improvements have been suggested by the experience of the first, more or less of these must be altered. When, however, two or three machines have been completed, and many more are wanted, they can usually be produced at much less than one-fifth of the expense of the original invention.

248. The arts of contriving, of drawing, and of executing, do not usually reside in their greatest perfection in one individual; and in this, as in other arts, *the division of labor* must be applied. The best advice which can be offered to a projector of any mechanical invention, is to employ a respectable draughtsman, who, if he has had a large experience in his profession, will assist in finding out whether the contrivance is new, and can then make working drawings of it. The first step, however, the ascertaining whether the contrivance has the merit of novelty, is most important; for it is a maxim equally just in all arts, and in every science, that the man who aspires to for-

tune or to fame by new discoveries, must be content to examine with care the knowledge of his contemporaries, or to exhaust his efforts in inventing again what he will, most probably, find has been better executed before.

This, nevertheless, is a subject upon which even ingenious men are often singularly negligent. There is, perhaps, no trade or profession existing in which there is so much quackery, so much ignorance of the scientific principles, and of the history of their own art, with respect to its resources and extent, as is to be met with amongst mechanical projectors. The self-constituted engineer, dazzled with the beauty of some, perhaps, really original contrivances, assumes his new profession with as little suspicion that previous instruction, that thought and painful labor, are necessary to its successful exercise, as does the statesman, or the senator. Much of this false confidence arises from the improper estimate which is entertained of the difficulty of invention in mechanics ; and it is of great importance, to the individuals, and to the families of those who are thus led away from more suitable pursuits, the dupes of their own ingenuity and of the popular voice, to convince both them and the public that the power of making new mechanical combinations is a possession common to a multitude of minds, and that it by no means requires talents of the highest order. It is still more important that they should be convinced that the great merit and the great success, of those who have attained to eminence in such matters, was almost entirely due to the unremitted perseverance with which they concentrated upon the successful invention the skill and knowledge which years of study had matured.

PROPER CIRCUMSTANCES FOR THE APPLICATION OF MACHINERY.

249. The first object of machinery, and the chief cause of its extensive utility, is the cheap production of the articles to which it is applied. Wherever it is required to produce a great multitude of things, all of exactly the same kind, the proper time has arrived for the construction of tools or machines by which they may be manufactured. If only a few pairs of cotton stockings should be required in a country, or in circumstances in which it is impossible to purchase them, it would be an absurd waste of time, and of capital, to construct a stocking-frame to weave them, when, for a few pence, four steel wires can be procured, by which they may be knit. If, on the other hand, many thousand pairs were wanted, the time employed, and the expense incurred, in constructing a stocking-frame, would be more than repaid by the saving of time in making that large number of stockings. The same principle is applicable to the copying of letters : if only three or four copies are required, the pen and the human hand furnish the cheapest resource ; but, if hundreds are called for, lithography may be brought to our assistance ; and if hundreds of thousands are wanted, the machinery of a printing establishment is the most economical method of accomplishing the object.

250. There are, however, many cases in which machines or tools must be made, where economical production is not the most important object. Whenever it is required to produce a few articles—parts of machinery, for instance,—which must be executed with the most rigid accuracy or be perfectly alike, it becomes nearly impossible to fulfil this condition, even with the aid of the most skilful hands. In such circumstances, it is necessary to make tools expressly for the purpose, although these tools should, as frequently happens, cost more in constructing than the things they are destined to make.

251. Another instance of the just application of machinery, even at an increased expense, arises where the shortness of time in which the article can be produced has an important influence on its value. In the publication of our daily newspapers, it frequently happens that the debates in the Houses of Parliament are carried on to three and four o'clock in the morning—that is, to within a very few hours of the time for the publication of the newspaper. The speeches must be taken down by reporters, conveyed by them to the establishment of the newspaper, perhaps at the distance of one or two miles, transcribed by them in the office, set up by the compositor, the press corrected, and the papers be printed off and distributed before the public can read them. Some of these journals have a circulation of from five to ten thousand daily. Supposing four thousand to be wanted, and that they could be printed only at the rate of five hundred per hour upon one side of the paper, (which was the greatest number two journeymen and a boy could take off by the old hand-presses,) sixteen hours would be required for printing the complete edition ; and the news conveyed to the purchasers of the latest portion of the impression, would be out of date before they could receive it. To obviate this difficulty, it was often necessary to set up the paper in duplicate, and sometimes, when late, in triplicate : but the improvements in the printing machines have been so great, that four thousand copies are now printed on one side in a hour.

252. The establishment of "The Times" newspaper is an example, on a large scale, of a manufactory in which the division of labor, both mental and bodily, is admirably illustrated, and in which also the effect of the domestic economy is well exemplified. It is scarcely imagined, by the thousands who read that paper in various quarters of the globe, what a scene of organized activity the factory presents during the whole night, or what a quantity of talent and mechanical skill is put in action for their amusement and information.* Nearly a

* The Author of these pages, with one of his friends, was recently induced to visit this most interesting establishment, after midnight, during the progress of a very important debate. The

hundred persons are employed in this establishment; and, during the session of Parliament, at least twelve reporters are constantly attending the Houses of Commons and Lords; each in his turn, after about an hour's work, retiring, to translate into ordinary writing the speech he has just heard and noted in shorthand. In the mean time fifty compositors are constantly at work, some of whom have already set up the beginning, whilst others are committing to type the yet undried manuscript of the continuation of a speech, whose middle portion is travelling to the office in the pocket of the hasty reporter, and whose eloquent conclusion is, perhaps, at that very moment, making the walls of St. Stephen's vibrate with the applause of its hearers. These congregated types, as fast as they are composed, are passed in portions to other hands; till at last the scattered fragments of the debate, forming, when united with the ordinary matter, eight and forty columns, re-appear in regular order on the platform of the printing press. The hand of man is now too slow for the demands of his curiosity, but the power of steam comes to his assistance. Ink is rapidly supplied to the moving types, by the most perfect mechanism: four attendants incessantly introduce the edges of large sheets of white paper to the junction of two great rollers, which seem to devour them with unsated appetite; other rollers convey them to the type already inked, and having brought them into rapid and successive contact, re-deliver them to four other assistants, completely printed by the almost momentary touch. Thus, in one hour, four thousand sheets of paper are printed on one side; and an impression of twelve thousand copies, from above three hundred thousand moveable pieces of metal, is produced for the public in six hours.

253. The conveyance of letters is another case, in which the importance of saving time would allow of great expense in any new machinery for its accomplishment. There is a natural limit to the speed of horses, which even the greatest improvements in the breed, aided by an increased perfection in our roads, can never surpass; and from which, perhaps, we are at present not very remote. When we reflect upon the great expense of time and money which the last refinements of a theory or an art usually require, it is not unreasonable to suppose that the period has arrived in which the substitution of machinery for such purposes ought to be tried.

254. The post-bag, despatched every evening by the mail to one of our largest cities, Bristol, usually weighs less than a hundred pounds. Now, the first reflection which naturally presents itself is, that, in order to transport these letters a hundred and twenty miles, a coach and apparatus weighing above thirty hundred weight is put in motion, and also conveyed over the same space.*

It is obvious that, amongst the conditions of machinery for accomplishing such an object, it would be desirable to reduce the weight of matter to be conveyed with the letters: it would also be desirable to reduce the velocity of the animal power employed; because the faster a horse is driven, the less weight he can draw. Amongst the variety of contrivances which might be imagined for this purpose, we will mention one, which, although by no means free from objections, fulfils some of the prescribed conditions, and is not a purely theoretical speculation; since some few experiments, though on an extremely limited scale, have been made upon it.

255. Let us imagine a series of high pillars erected at frequent intervals, perhaps every hundred feet, as nearly as possible in a straight line between the two post towns. An iron or steel wire of some thickness must be stretched over proper supports, fixed on each of these pillars, and terminating at the end of every three or five miles, as may be found expedient, in a very strong support, by which it may be stretched. At each of these latter points a man ought to reside, in a small station-house. A narrow cylindrical tin case, to contain the letters, might be suspended by two wheels rolling upon this wire: these might be so constructed as to enable them to pass unimpeded by the fixed supports of the wire. An endless wire of much smaller size must pass over two drums, one at each end. This wire should be supported on rollers, fixed to the supports of the great wire, and at a short distance below it. With this arrangement, there would be the two branches of the smaller wire always accompanying the larger one; and the attendant at either station might, by turning the drum, cause these two branches of the small wire to move with great velocity in opposite directions. In order to convey the cylinder which contains the letters, it would only be necessary to attach it,

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place was illuminated with gas, and was light as the day: there was neither noise nor bustle: and the visitors were received with such calm and polite attention, that they did not, until afterwards, become sensible of the inconvenience which such intruders, at a moment of the greatest pressure, must occasion, nor reflect that the tranquillity which they admired was the result of intense and regulated occupation. But the effect of such checks in the current of business will appear on recollecting that, as four thousand newspapers are printed off on one side within the hour, every *minute* is attended with a loss of sixty-six impressions. *The quarter of an hour, therefore, which* the stranger may think it not unreasonable to claim for the gratification of his curiosity, (and to him this time is but a moment,) may cause a *failure in the delivery of one thousand* copies, and disappoint a proportionate number of expectant readers, in some of our distant towns, to which the morning papers are despatched *by the earliest and most rapid conveyances* of each day.—This note is inserted with the farther and more general purpose of calling the attention of those, especially foreigners, who are desirous of inspecting our larger manufactories, to the chief cause of the difficulty which frequently attends their introduction. When the establishment is very extensive, and its departments skilfuly arranged, the exclusion of visitors arises, not from any illiberal jealousy, nor, generally, from any desire of concealment, which would in most cases be absurd, but from the substantial inconvenience and loss of time, throughout an entire series of well combined operations, which must be occasioned even by short and casual interruptions.

* It is true that the transport of letters is not the only object which this apparatus answers; but the transport of passengers, which is a secondary object, does, in fact, put a limit to the velocity of that of letters, which is the primary one.

by a string, or by a catch, to either of the branches of the endless wire. Thus it would be conveyed speedily to the next station, where it would be removed by the attendant to the commencement of the next wire, and thus transmitted on. It is unnecessary to enter into the details which this, or any similar plan, would require. The difficulties are obvious; but if these were overcome, it would present many advantages besides velocity: for if an attendant reside at each station, the additional expense of having two or three deliveries of letters every day, and even of sending expresses at any moment, would be comparatively trifling; and it is not impossible that the stretched wire might itself be available for a species of telegraphic communication yet more rapid.

Perhaps if the steeples of churches, properly selected, were made use of, connecting them by a few intermediate stations with some great central building, as, for instance, with the top of St. Paul's; and if a similar apparatus were placed on the top of each steeple, and a man to work it during the day, it might be possible to diminish the expense of the two-penny post, and make deliveries every half hour over the greater part of the metropolis.

256. The power of steam, however, bids fair almost to rival the velocity of these contrivances; and the fitness of its application to the purposes of conveyance, particularly where great velocity is required, is now beginning to be generally admitted. The following extract from the Report of the Committee of the House of Commons on steam carriages explains clearly its various advantages:

"Perhaps one of the principal advantages resulting from the use of steam will be that it may be employed as cheaply at a quick as at a slow rate; 'this is one of the advantages over horse labor, which becomes more and more expensive as the speed is increased. There is every reason to expect that, in the end, the rate of travelling by steam will be much quicker than the utmost speed of travelling by horses; in short, the safety to travellers will become the limit to speed.' In horse draught the opposite result takes place: in 'all cases horses lose power of draught in a much greater proportion than they gain speed, and hence the work they do becomes more expensive as they go quicker.'

"Without increase of cost, then, we shall obtain a power which will insure a rapidity of internal communication far beyond the utmost speed of horses in draught; and although the performance of these carriages may not have hitherto attained this point, when once it has been established, that at equal speed we can use steam more cheaply in draught than horses, we may fairly anticipate that every day's increased experience in the management of the engines will induce greater skill, greater confidence, and greater speed.

"The cheapness of the conveyance will probably be for some time a secondary consideration. If, at present, it can be used as cheaply as horse power, the competition with the former modes of conveyance will first take place as to speed. When once the superiority of steam carriages shall have been fully established, competition will induce economy in the cost of working them. The evidence, however, of Mr. Macneill, showing the greater efficiency, with diminished expenditure of fuel, by locomotive engines on railways, convinces the committee that experience will soon teach a better construction of the engines, and a less costly mode of generating the requisite supply of steam.

"Nor are the advantages of steam power confined to the greater velocity attained, or to its greater cheapness than horse draught. In the latter, danger is increased, in as large a proportion as expense, by greater speed. In steam power, on the contrary, 'there is no danger of being run away with, and that of being overturned is greatly diminished. It is difficult to control four such horses as can draw a heavy carriage ten miles per hour, in case they are frightened, or choose to run away; and for quick travelling, they must be kept in that state of courage that they are always inclined for running away, particularly down hills, and at sharp turns of the road. In steam, however, there is little corresponding danger, being perfectly controllable, and capable of exerting its power in reverse in going down hills.' Every witness examined has given the fullest and most satisfactory evidence of the perfect control which the conductor has over the movement of the carriage. With the slightest exertion it can be stopped or turned, under circumstances where horses would be totally unmanageable."

257. Another instance may be mentioned in which the object to be obtained is so important, that although it might be rarely wanted, yet machinery for that purpose would justify considerable expense. A vessel to contain men, and to be navigated at some distance below the surface of the sea, would in many circumstances be almost invaluable. Such a vessel, evidently, could not be propelled by any engine requiring the aid of fire. If, however, by condensing air into a liquid, and carrying it in that state, a propelling power could be procured sufficient for moving the vessel through a considerable space, the expense would scarcely render its occasional employment impossible.*

258. *Slide of Alpnach.*—Amongst the forests which flank many of the lofty mountains of Switzerland, some of the finest timber is found in positions almost inaccessible. The expense of roads, even if it were possible to make them in such situations, would prevent the inhabitants from deriving any advantages from these almost inexhaustible supplies. Placed by nature at a considerable elevation above the spot on which they are required, they are precisely in fit circumstances for the application of machinery; and the inhabitants constantly avail

* A proposal for such a vessel, and description of its construction, may be found in the Encyclopædia Metropolitana, art. "Diving Bell."

themselves of it, to enable the force of gravity to relieve them from some portion of their labor. The inclined planes which they have established in various forests, by which the timber has been sent down to the water-courses, must have excited the admiration of every traveller; and these slides, in addition to the merit of simplicity, have that of economy, as their construction requires scarcely any thing beyond the material which grows upon the spot. Of all these specimens of carpentry, the Slide of Alpnach was by far the most considerable, both from its great length and from the almost inaccessible position from which it descended. The following is the description of that work given in Gilbert's Annalen, 1819, and translated in the second volume of Brewster's Journal:

"For many centuries, the rugged flanks and the deep gorges of Mount Pilatus were covered with impenetrable forests. Lofty precipices encircled them on all sides. Even the daring hunters were scarcely able to reach them; and the inhabitants of the valley had never conceived the idea of disturbing them with the axe. These immense forests were therefore permitted to grow and to perish, without being of the least utility to man, till a foreigner, conducted into their wild recesses in the pursuit of the chamois, was struck with wonder at the sight, and directed the attention of several Swiss gentlemen to the extent and superiority of the timber. The most intelligent and skilful individuals, however, considered it quite impracticable to avail themselves of such inaccessible stores. It was not till November, 1816, that M. Rupp, and three Swiss gentlemen, entertaining more sanguine hopes, drew up the plan of a slide, founded on trigonometrical measurements. Having purchased a certain extent of the forests from the commune of Alpnach for 6,000 crowns, they began the construction of the slide, and completed it in the spring of 1818.

"The slide of Alpnach is formed entirely of about 25,000 large pine trees, deprived of their bark, and united together in a very ingenious manner, without the aid of iron. It occupied about 160 workmen during 18 months, and cost nearly 100,000 francs, or £4,250. It is about 3 leagues, or 44,000 English feet long, and terminates in the Lake of Lucerne. It has the form of a trough, about six feet broad, and from three to six feet deep. Its bottom is formed of three trees, the middle one of which has a groove cut out in the direction of its length, for receiving small rills of water, which are conducted into it from various places, for the purpose of diminishing the friction. The whole of the slide is sustained by about two thousand supports; and in many places it is attached, in a very ingenious manner, to the rugged precipices of granite.

"The direction of the slide is sometimes straight, and sometimes zig-zag, with an inclination of from ten to eighteen degrees. It is often carried along the sides of hills and the flanks of precipitous rocks, and sometimes passes over their summits. Occasionally it goes under ground, and at other times it is conducted over the deep gorges by scaffoldings 120 feet in height.

"The boldness which characterizes this work, the sagacity displayed in all its arrangements, and the skill of the engineer, have excited the wonder of every person who has seen it. Before any step could be taken in its erection, it was necessary to cut several thousand trees to obtain a passage through the impenetrable thickets; and, as the workmen advanced, men were posted at certain distances, in order to point out the road for their return, and to discover, in the gorges, the places where the piles of wood had been established. M. Rupp was himself obliged, more than once, to be suspended by cords, in order to descend precipices many hundred feet high; and in the first months of the undertaking, he was attacked with a violent fever, which deprived him of the power of superintending his workmen. Nothing, however, could diminish his invincible perseverance. He was carried every day to the mountain in a barrow, to direct the labors of the workmen, which was absolutely necessary, as he had scarcely two good carpenters among them all—the rest having been hired by accident, without any of the knowledge which such an undertaking required. M. Rupp had also to contend against the prejudices of the peasantry. He was supposed to have communion with the devil. He was charged with heresy, and every obstacle was thrown in the way of an enterprize which they regarded as absurd and impracticable. All these difficulties, however, were surmounted, and he had at last the satisfaction of observing the trees descend from the mountain with the rapidity of lightning. The larger pines, which were about a hundred feet long, and ten inches thick at their smaller extremity, ran through the space of *three leagues*, or nearly *nine miles, in two minutes and a half*, and during their descent they appeared to be only a few feet in length. The arrangements for this part of the operation were extremely simple. From the lower end of the slide to the upper end, where the trees were introduced, workmen were posted at regular distances, and as soon as every thing was ready, the workman at the lower end of the slide cried out to the one above him, "*Lachez*" (Let go). The cry was repeated from one to another, and reached the top of the slide in three minutes. The workman at the top of the slide then cried out to the one below him, "*Il vient*" (It comes), and the tree was instantly launched down the slide, preceded by the cry which was repeated from post to post. As soon as the tree had reached the bottom, and plunged into the lake, the cry of *Lachez* was repeated as before, and a new tree was launched in a similar manner. By these means a tree descended every five or six minutes, provided no accident happened to the slides, which sometimes took place, but which was instantly repaired when it did.

"In order to show the enormous force which

the trees acquired from the great velocity of their descent, M. Rupp made arrangements for causing some of the trees to spring from the slide. They penetrated by their thickest extremities no less than from eighteen to twenty-four feet into the earth; and one of the trees having by accident struck against the other, it instantly cleft it through its whole length, as if it had been struck by lightning.

"After the trees had descended the slide, they were collected into rafts upon the lake, and conducted to Lucerne. From thence they descended the Reuss, then the Aar to near Brugg, afterwards to Waldshut by the Rhine, then to Basle, and even to the sea, when it was necessary.

"In order that none of the small wood might be lost, M. Rupp established in the forest large manufactories of charcoal. He erected magazines for preserving it when manufactured, and had made arrangements for the construction of barrels for the purpose of carrying it to the market. In winter, when the slide was covered with snow, the barrels were made to descend on a kind of sledge. The wood which was not fit for being carbonized, was heaped up and burnt, and the ashes packed up and carried away, during the winter.

"A few days before the author of the preceding account visited the slide, an inspector of the navy had come for the purpose of examining the quality of the timber. He declared that he had never seen any timber that was so strong, so fine, and of such a size; and he concluded an advantageous bargain for a thousand trees.

"Such is a brief account of a work undertaken and executed by a single individual, and which has excited a very high degree of interest in every part of Europe. We regret to add that this magnificent structure no longer exists, and that scarcely a trace of it is to be seen upon the flanks of Mount Pilatus. Political circumstances having taken away the principal source of the demand for timber, and no other market having been found, the operation of cutting and transporting the trees necessarily ceased."

Professor Playfair, who visited this singular slide, states that six minutes was the usual time occupied in the descent of a tree; but that, in wet weather, it reached the lake in three minutes.

259. One of the most common effects of the introduction of new machinery into manufactures, is to drive out of employment much of the hand-labor which was previously used. This, for a time, produces a considerable suffering amongst the working classes; and it is of great importance for their happiness that they should be aware of the effects, and that they should be enabled to foresee them at an early period, in order to diminish as much as possible their injurious results. It is almost the invariable consequence of such improvements, ultimately to cause a greater demand for labor; and often the new labor requires a higher degree of skill than the old: but, unfortunately, the class of persons who have been driven out of the old employment are not always qualified for the new one; and in all cases, a considerable time elapses before the whole of their labor is wanted. One very important inquiry which this subject presents is the question—*Whether it is for the interest of the working classes, that any improved machinery should be so perfect as to defy the competition of hand-labor, and that they should be at once driven out of the trade by it; or whether it is more advantageous for them to be gradually forced to quit the trade by the slow and successive advances of the machine?* The suffering which arises from a quick transition is undoubtedly more intense; but it is also much less permanent than that which results from the slower process. If the competition is perceived at once to be perfectly hopeless, the workman will at once set himself to learn a new department of his art. The use of power-looms is an instance of a slow change, which has gradually been diminishing the wages of the hand-weavers. It appears that the number of hand-looms in use in England and Scotland in 1830 was about 240,000; nearly the same number existed in the year 1820; whereas the number of power-looms which in 1820 was 14,000, had in 1830 increased to 55,000. When it is considered that each of these looms at that time did as much work as three hand-looms, the increased amount of work produced was equal to that of 123,000 hand-looms. During the whole of this period the wages and employment of hand-loom weavers has been very precarious.

260. Increased intelligence amongst the working classes may enable them to foresee some of those improvements which are likely for a time to affect the value of their labor; and the assistance of Savings Banks and Friendly Societies, (the advantages of which can never be too frequently, or too strongly, pressed upon their attention,) may be of some avail in remedying the evil: but it seems also desirable to suggest to them, that a diversity of employment amongst the members of one family, will tend, in some measure, to mitigate the privations which arise from fluctuation in the value of labor.

ON THE DURATION OF MACHINERY.

261. The time during which a machine will continue effectually to perform its work, will depend mainly upon the perfection with which it was originally constructed, upon the care taken to keep it in proper repair, particularly to correct every shake or looseness in the axes, and upon the small mass and slow velocity of its moving parts. Every thing approaching to a blow, all sudden change of direction, is injurious. Engines for producing power, such as wind mills, water mills, and steam engines, usually last a long time.* But machinery for producing any commodity in great demand sel-

* The return which ought to be produced by a fixed steam engine employed as a moving power is frequently estimated at ten per cent. on its cost.

dom actually wears out; new improvements, by which the same operations can be executed either more quickly or better, generally superceding it long before that period arrives: indeed, to make such an improved machine profitable, it is usually reckoned that in five years it ought to have paid itself, and in ten to be superceded by a better.

"A cotton manufacturer," says one of the witnesses before a Committee of the House of Commons, "who left Manchester seven years ago, would be driven out of the market by the men who are now living in it, provided his knowledge had not kept pace with those who have been during that time constantly profiting by the progressive improvements that have taken place in that period."

262. The effect of improvements in machinery seems incidentally to increase production, through a cause which may be thus explained. A manufacturer, making the usual profit upon his capital invested in looms or other machines in perfect condition, the market price of making each of which is a hundred pounds, invents some improvement. But this is of such a nature that it cannot be adapted to his present engines. He finds upon calculation, that at the rate at which he can dispose of his manufactured produce, each new engine would repay the cost of its making, together with the ordinary profit of capital, in three years: he also concludes from his experience of the trade, that the improvement he is about to make will not be generally adopted by other manufacturers before that time. On these considerations, it is clearly his interest to sell his present engines, even at half price, and construct new ones on the improved principle. But the purchaser who gives only fifty pounds for the old engines has not so large a fixed capital invested in his factory, as the person from whom he purchased them; and as he produces the same quantity of the manufactured article, his profits will be larger. Hence, the price of the commodity will fall, not only in consequence of the cheaper production by the new machinery, but also by the more profitable working of the old, when sold at a reduced price. This change, however, can be only transient; for a time will arrive when the old machinery, although in good repair, must become worthless. The improvement which took place not long ago in frames for making patent-net was so great, that a machine, in good repair, which had cost £1200, sold a few years after for £60. During the great speculations in that trade the improvements succeeded each other so rapidly, that machines which had never been finished were abandoned in the hands of their makers, because new improvements had superceded their utility.

263. The durability of common watches, when well made, is very considerable. One was produced, in "*going order*," before a committee of the House of Commons to inquire into the watch trade, which was made in the year 1660; and there are many of ancient date in the possession of the Clock-makers' Company, which are actually kept going. The number of watches manufactured for home consumption was, in the year 1798, about 50,000 annually. If this supply was for Great Britain only, it was consumed by about ten and a half millions of persons.

264. Machines are, in some trades, let out to hire, and a certain sum is paid for their use in the manner of rent. This is the case amongst the frame-work knitters: and Mr. Henson, in speaking of the rate of payment for the use of their frames, states, that the proprietor receives such a rent that, besides paying the full interest for his capital, he clears the value of his frame in nine years. When the rapidity with which improvements succeed each other is considered, this rent does not appear exorbitant. Some of these frames have been worked for thirteen years with little or no repair. But circumstances occasionally arise which throw them out of employment, either temporarily or permanently. Some years since, an article was introduced called "*cut-up work*," by which the price of stocking frames was greatly deteriorated. From the evidence of Mr. J. Rawson, it appears that, in consequence of this change in the nature of the work, *each frame could do the work of two*, and many stocking frames were thrown out of employment, and their value reduced *full three-fourths*.*

This information is of great importance, if the numbers here given are nearly correct, and if no other causes intervened to diminish the price of frames; for it shows the numerical connection between the increased production of those machines and their diminished value.

The great importance of simplifying all transactions between masters and workmen, and of dispassionately discussing with the latter the influence of any proposed regulations, is well exemplified by a mistake into which both parties unintentionally fell, and which was productive of very great misery. Its history is so well told by William Allen, a frame-work knitter, who was a party to it, that an extract from his evidence, as given before the Frame-work Knitters' Committee of 1812, will best explain it.

"I beg to say a few words respecting the frame-rent: the rent paid for lace-frames, until the year 1805, was 1*s*. 6*d*. a frame per week; there then was not any very great inducement for persons to buy frames and let them out by the hire, who did not belong to the trade; at that time an attempt was made, by one or two houses, to reduce the prices paid to the workmen, in consequence of a dispute between these two houses and another great house. Some little difference being paid in the price among the respective houses, I was one chosen by the workmen to try if we could not remedy the impending evil: we consulted the respective

* Report from the Committee of the House of Commons on the Frame-Work Knitters' Petition, April, 1819.

parties, and found them inflexible; these two houses, that were about to reduce the prices, said that they would either immediately reduce the price of making net, or they would increase the frame-rent: the difference to the workmen was considerable, between the one and the other; they would suffer less, in the immediate operation of the thing, by having the rent advanced, than the price of making net reduced. They chose at that time, as they thought, the lesser evil, but it has turned out to be otherwise; for, immediately as the rent was raised upon the per-centage laid out in frames, it induced almost every person, who had got a little money, to lay it out in the purchase of frames; these frames were placed in the hands of men who could get work for them at the warehouses; they were generally constrained to pay an enormous rent, and then they were compelled, most likely, to buy of the persons that let them the frames their butcher's-meat, their grocery, or their clothing: the encumbrance of these frames became entailed upon them: if any deadness took place in the work they must take it at a very reduced price, for fear of the consequences that would fall upon them from the person who bought the frame; thus the evil has been daily increasing, till, in conjunction with the other evils crept into the trade, they have almost crushed it to atoms."

265. The evil of not assigning fairly to each tool, or each article produced, its *proportionate value*, or even of not having a perfectly distinct, simple, and definite *agreement* between a master and his workmen, is very considerable Workmen find it difficult to know the probable produce of their labor; and both parties are often led to adopt arrangements, which, had they been well examined, would have been rejected as equally at variance in the results with the true interests of both.

266. At Birmingham, stamps and dies, and presses, for a great variety of articles, are let out: they are generally made by men possessing small capital, and are rented by workmen. Power also is rented at the same place. Steam engines are erected in large buildings containing a variety of rooms, in which each person may hire one, two, or any other number of horse power, as his occupation may require. If any mode could be discovered of transmitting power, without much loss from friction, to considerable distances, and at the same time of registering the quantity made use of at any particular point, a considerable change would probably take place in many parts of the present system of manufacturing. A few central engines to produce power might then be erected in our great towns, and each workman, hiring a quantity of power sufficient for his purpose, might have it conveyed into his own house; and thus a transition might in some instances be effected, if it should be found more profitable, from the system of great factories back to that of domestic manufacture.

267. The transmission of water through a system of pipes might be employed for the distribution of power, but the friction would consume a considerable portion. Another method has been employed in some instances, and is practised at the Mint. It consists in exhausting the air from a large vessel by means of a steam-engine. This vessel is connected by pipes, with a small piston, which drives each coining press; and, on opening a valve, the pressure of the external air forces in the piston. This air is then admitted to the general reservoir, and pumped out by the engine. The condensation of air might be employed for the same purpose; but it must be admitted that there are some unexplained facts relative to that elastic fluid, which require farther observations and experiment before it can be used for the conveyance of power to any considerable distance. It has been found, for instance, in attempting to blow a furnace by means of a powerful water wheel driving air through a cast-iron pipe of above a mile in length, that scarcely any sensible effect was produced at the opposite extremity. In one instance, some accidental obstruction being suspected, a cat put in at one end found its way out without injury at the other, thus proving that the phenomenon did not depend on interruption within the pipe.

268. The most portable form in which power can be condensed is, perhaps, by the liquefaction of the gases. It is known that, under considerable pressure, several of these became liquid at ordinary temperatures. Carbonic acid, for example, requires a pressure of sixty atmospheres to reduce it to a liquid state. One of the advantages attending the use of these fluids is, that the pressure exerted by them remains constant until the last drop of liquid becomes gaseous. If either of the elements of common air should be found to be capable of reduction to a liquid state before it unites into a corrosive fluid with the other ingredient, then we shall possess a ready means of conveying power in any quantity and to any distance. Probably hydrogen will require the strongest compressing force to render it liquid, and may, therefore, possibly be applied where still greater condensation of power is wanted. In all these cases the condensed gases may be looked upon as enormous springs, which have been wound up by the exertion of power, and which will deliver the whole of it back again when required. These springs of nature differ in some respects from the steel springs formed by our art; for in the compression of the natural springs an enormous quantity of latent heat is forced out, and in their return to the state of gas an equal quantity is absorbed. May not this very property be employed with advantage in these applications?

The mechanical difficulty which will remain to be overcome will consist in the valves and packing necessary to retain the fluids under the pressures to which they will be submitted; and the effect of heat on these gases has not yet been sufficiently tried to lead us to any very

precise notions of the additional power which its application to them will supply.

The elasticity of air is sometimes employed as a spring instead of steel: in one of the large printing presses the momentum of a considerable mass of matter is destroyed, by making it condense the air included in a cylinder, by means of a piston, against which it impinges.

269. The effect of competition in cheapening articles of manufacture sometimes operates in rendering them less durable. When such articles are conveyed, for consumption, to a distance from the place where they are made, if they are broken, it often happens, from the different price of labor, that it is more expensive to mend the old than to purchase a new article. Such is usually the case, in great cities, with some of the commoner locks, with hinges, and with a variety of articles of hardware.

ON COMBINATIONS AMONGST MASTERS OR WORKMEN, AGAINST EACH OTHER.

270. There exist amongst the workmen of almost all classes, certain rules or laws which govern their actions towards each other, and towards their employers. But besides these general principles, there are frequently others peculiar to each factory, which have derived their origin, in many instances, from the mutual convenience of the parties engaged in them. Such rules are little known, except to those actually pursuing the several trades; and as it is of importance that their advantages and disadvantages should be canvassed, we shall offer a few remarks upon some of them.

271. The principles by which such laws should be tried are—

First, That they conduce to the general benefit of the whole of the persons employed;

Secondly, That they prevent fraud;

Thirdly, That they interfere as little as possible with the free agency of each individual.

272. It is usual in many workshops, that, on the first entrance of a new journeyman, he shall pay a small fine to the rest of the men. It is clearly unjust to insist upon this payment; and when it is spent in drinking, which is unfortunately too often the case, it is injurious. The reason assigned for the demand is that the new comer will require some instruction in the habits of the shop, and in the places of the different tools, and will thus waste the time of some of his companions until he is instructed. If this fine were added to a fund, managed by the workmen of the establishment, and divided at given periods, or destined for their relief in sickness, it would be less objectionable, since its tendency would be to check the too frequent change of the men from one shop to another. But it ought, at all events, not to be compulsory; and the advantages to be derived from the fund to which the workman is invited to subscribe ought to be his sole inducement.

273. In many workshops, the workmen, although employed on totally different parts of the objects manufactured, are yet dependent in some measure upon each other. Thus, a single smith may be able to forge in one day work enough to keep four or five turners employed during the next. If, from idleness or intemperance, the smith neglects his work, and does not furnish the usual supply, the turners (supposing them to be paid by the piece) will have their time partly unoccupied, and their gains consequently diminished. It is reasonable, in such circumstances, that a fine should be levied, in order to prevent their recurrence; but it is desirable that the master should have concurred with his workmen in establishing such a rule, and that it should be shown to each individual previous to his engagement; and it is very desirable that such fine should not be spent in drinking.

274. In some establishments it is customary for the master to give a small gratuity whenever any workman has exercised a remarkable degree of skill, or has economized the material employed. Thus, in splitting horn into layers for lanterns, one horn usually furnishes from five to eight layers; but if a workman split the horn into ten layers or more, he receives a pint of ale from the master. These premiums should not be too high, lest the material should be wasted by the workman in unsuccessful attempts; but such regulations, when judiciously made, are beneficial, as they tend to promote skill amongst the men, profit to the masters, and diminished cost to the consumers.

275. In some few factories in which the men are paid by the piece, it is usual, when any portion of work delivered in by a workman is rejected by the master on account of its being badly executed, to fine the delinquent. Such a practice tends to remedy one of the evils attendant upon that mode of payment, and greatly assists the master, since his own judgment is thus supported by competent and unprejudiced judges.

276. Societies exist amongst some of the larger bodies of workmen, and there are also others formed by the masters engaged in the same branches of trade. These have different objects in view; but it is very desirable that their effects should be well understood by the individuals who compose them; and that the advantages arising from them, which are certainly great, should be separated as much as possible from the evils which they have unfortunately too frequently introduced. Associations of workmen and of masters may with advantage agree upon rules to be observed by both parties, in the estimation of the proportionate value of various kinds of work executed in their trade, in order that time may be saved, and disputes between them may be prevented. They may also be most usefully employed in acquiring accurate information of the number of persons working in the various departments of any manufacture, their rate of wages, the number of machines in use among them, and other statistical details. Information of this nature is extremely valuable, both for the guidance of the

parties who are themselves most interested, and also to enable them, on any application to government for assistance, or with a view to legislative enactments, to supply those details, without which the propriety of any proposed measure cannot be fitly decided upon. Such details may be collected by men actually engaged in any branch of trade at a much smaller expense of time than by persons less acquainted with and less interested in it.

277. One of the most legitimate and most important objects of such associations as we have just mentioned is to agree upon ready and certain modes of measuring the quantity of work done by the workmen. For a long time a difficulty upon this point existed in the lace trade, which was justly complained of by the men as a serious grievance; but the introduction of the "*rack*," which counts the number of holes in the length of the piece, has entirely put an end to the most fertile cause of disputes. This was adverted to by the Committee of 1812, and a hope expressed that the same contrivance would be applied to stocking frames. It would, indeed, be of great mutual advantage to the industrious workman and to the master-manufacturer in every trade, if the machines employed in it could register the quantity of work done, in the same manner as a steam engine does the number of strokes it makes. The introduction of such contrivances gives a greater stimulus to honest industry than can readily be imagined, and removes one of the sources of disagreement between parties whose real interests must always suffer by any estrangement between them.

278. The effects arising from combinations amongst the workmen are almost always injurious to the parties themselves. There are numerous instances in which the public suffer by increased price at the moment, but are ultimate gainers from the permanent reduction which results; whilst, on the other hand, the improvements which are often made in machinery, in consequence of "a strike" amongst the workmen, most frequently do an injury of greater or less duration to that particular class which gave rise to them. As the injury to the men and to their families is almost always greater than that which affects their employers, it is of the utmost importance to the comfort and happiness of the former class that sound views should be entertained by them upon this question. For this purpose a few illustrations of the principle which is here maintained will probably have greater weight than any reasoning of a more general nature, though drawn from admitted principles of political economy. Such instances will, moreover, present the additional advantage of appealing to facts known to many individuals of those classes for whose benefit these reflections are intended.

279. There is a process in the manufacture of gun barrels, for making what, in the language of the trade, are called *skelps*. The *skelp* is a piece or bar of iron, about three feet long, and four inches wide, but thicker and broader at one end than at the other; and the barrel of a musket is formed by forging out such pieces to the proper dimensions, and then folding or bending them round into a cylindrical form, until the edges overlap, so that they can be welded together.

About twenty years ago, the workmen, employed at a very extensive factory in forging these skelps out of bar iron, "struck" for an advance of wages, and as their demands were very exorbitant, they were not immediately complied with. In the mean time, the superintendant of the establishment directed his attention to the subject; and it occurred to him, that if the circumference of the rollers between which the bar iron was rolled were to be made equal to the length of a *skelp*, or of a musket barrel, and if also the grooves in which the iron was compressed, instead of being equally deep and wide, were cut gradually deeper and wider from a point in the rollers until it returned to the same point, then the bar iron passing between such rollers, instead of being uniform in width and thickness, would have the form of a *skelp*. On making the trial, it was found to succeed perfectly; a great reduction of human labor was effected by the process, and the workmen who had acquired peculiar skill in forming it ceased to derive any advantage from their dexterity.

280. It is somewhat singular that another and a still more remarkable instance of the effect of combination amongst workmen should have occurred but a few years since in the very same trade. The process of welding the *skelps*, so as to convert them into gun barrels, required much skill; and after the termination of the war, the demand for muskets having greatly diminished, the number of persons employed in that line was very much reduced. This circumstance rendered combination more easy; and upon one occasion, when a contract had been entered into for a considerable supply to be delivered on a fixed day. the men all struck for such an advance of wages as would have caused the completion of the contract to be attended with a very heavy loss. In this difficulty, the contractors resorted to a mode of welding the gun barrel, according to a plan for which a patent had been taken out by them some years before this event. It had not then succeeded so well as to come into general use, in consequence of the cheapness of the usual mode of welding by hand labor, combined with some other difficulties with which the patentee had had to contend. But the stimulus produced by the combination of the workmen for this advance of wages induced him to make new trials, and he was enabled to introduce such a facility in welding gun barrels by rollers, and such perfection in the work itself, that, in all probability, very few will in future be welded by hand labor. The process consisted in turning a bar of iron, about a foot long, into the form of a cylinder, with the edges a little overlapping.

It was then placed in a furnace, raised to a welding heat, and taken out, when a triblet, or cylinder of iron, being placed in it, it was passed quickly through a pair of rollers. The effect of this was that the welding was performed at a single heating, and the remainder of the elongation necessary for bringing it to the length of the musket barrel was performed in a similar manner, but at a lower temperature. The workmen who had combined were of course no longer wanted; and instead of benefitting themselves by their combination, they were reduced permanently, by this improvement in the art, to a considerably lower rate of wages: for as the process to which they had been habituated required peculiar skill and considerable experience, they had hitherto been in the habit of earning much higher wages than other workmen of their class. On the other hand, the new method of welding was far less injurious to the texture of the iron, which was now exposed only once, instead of three or four times, to the welding heat: so that the public derived advantage from the superiority, as well as from the economy of the process. Another advantage has also arisen from its introduction: for the new process is now applied to the manufacture of iron tubes, which can thus be made at a price which renders their employment very general. They are now to be found in the shops of all our larger ironmongers, in various lengths, and of different diameters, with screws cut at each end; and are in constant use for the conveyance of gas for lighting, or of water for warming, our houses.

281. Similar examples must have presented themselves to those who are familiar with the details of our manufactories, but these are sufficient to illustrate one of the results of combinations. It would not, however, be fair to push the conclusion deduced from these instances to its extreme limit. Although it is very apparent that, in the two cases which have been stated, the effects of combination were permanently injurious to the workman, by almost immediately placing him in a lower class (with respect to his wages) than he occupied before, yet they do not prove that *all* such combinations have this *effect*. It is quite evident that they have all this *tendency;* it is also certain that considerable stimulus must be applied to induce a man to contrive a new and expensive process; and that in both these cases, unless the fear of pecuniary loss had acted powerfully, the improvement would not have been made. If, therefore, the workmen had in either case combined for only a small advance of wages, they would in all probability have been successful, and the public would have been deprived for many years of the inventions to which these combinations gave rise. It must, however, be observed, that the same skill which enabled them to obtain, after long practice, higher wages than the rest of their class, would prevent many of them from being *permanently* thrown back into the class of ordinary workmen. Their diminished wages will continue only until they have acquired, by practice, a facility of execution in some other of the more difficult operations: but a diminution of wages, even for a year or two, is still a very serious inconvenience to any person who lives by his daily exertion. The consequence of combination has then, in these instances, been to the workmen who combined—reduction of wages; to the public—reduction of price; and, to the manufacturer—increased sale of his commodity, resulting from that reduction.

282. It is, however, important to consider the effects of combination in another and less obvious point of view. The fear of combination amongst the men whom he employs will have a tendency to induce the manufacturer to conceal from his workmen the extent of the orders he may at any time have in hand; and, consequently, they will always be less acquainted with the extent of the demand for their labor than they otherwise might. This is injurious to their interests: for instead of foreseeing, by the gradual falling off in the orders, the approach of a time when they must be unemployed, and preparing accordingly, they are liable to much more sudden changes than those to which they would otherwise be subject.

In the evidence given by Mr. Galloway, the engineer, he remarks that, "When employers are competent to show their men that their business is steady and certain, and when men find that they are likely to have permanent employment, they have always better habits and more settled notions; which will make them better men and better workmen, and will produce great benefits to all who are interested in their employment."

283. As the manufacturer, when he makes a contract, has no security that a combination may not arise amongst the workmen, which may render that contract a loss instead of a benefit, besides taking precautions to prevent them from becoming acquainted with it, he must also add to the price at which he could otherwise sell the article, some small increase, to cover the risk of such an occurrence. If an establishment consist of several branches, which can only be carried on jointly,—as, for instance, of iron mines, blast furnaces, or a colliery, in which there are distinct classes of workmen,—it becomes necessary to keep on hand a larger stock of materials than would be required, if it were certain that no combinations would arise. Suppose, for instance, the colliers were to "strike" for an advance of wages: unless there were a stock of coal above ground, the furnaces must be stopped, and the miners also would be thrown out of employ. Now, the cost of keeping a stock of iron ore, or of coals, above-ground, is just the same as that of keeping in a drawer, unemployed, its value in money, (except, indeed, that the coal suffers a small deterioration by exposure to the elements.) The interest of this sum must, therefore, be considered as the price of an insurance against the

risk of combination amongst the workmen; and it must, so far as it goes, increase the price of the manufactured article, and consequently limit the demand which would otherwise exist for it. But every circumstance which tends to limit the demand is injurious to the workmen; because the wider the demand, the less is it exposed to fluctuation. The effect to which we have alluded is by no means a theoretical conclusion: the proprietors of one establishment in the trade which has been mentioned think it expedient always to keep above-ground a supply of coal for six months, which is, in that instance, equal in value to about £10,000.

284. That combinations amongst workmen are productive of serious inconveniences to themselves, is admitted by all parties; and it is equally true, that, in many cases, a successful result does not leave them in as favorable a position as they were previous to the "strike." The little capital they possessed, which ought to have been hoarded with care for days of illness or distress, is exhausted; and frequently, in order to gratify a pride, at the existence of which we cannot but rejoice, even whilst we regret its misdirected energy, they will undergo the severest privations rather than return to work at their former wages. With many of the workmen, unfortunately, during such periods, habits of idleness are formed which it is difficult to eradicate; and, in all those engaged in such occurrences, the kinder feelings of the heart are chilled, and passions are called into action injurious to the happiness of the individual, and destructive of those sentiments of confidence which it is equally the interests of the master-manufacturer and of his workman to maintain. If any of the trade refuse to join in the "strike," the majority too frequently forget, in the excitement of their feelings, the dictates of justice, and endeavor to exert a species of tyranny, which can never be permitted to exist in a free country. In conceding, therefore, to the working classes, that they have a right, if they consider it expedient, to combine for the purpose of procuring higher wages (provided always, that they have completed all their existing contracts,) it ought ever to be kept before their attention, that the same freedom which they claim for themselves they must allow to others, who may have different views of the advantages of combination: and whilst every effort which reason and kindness can dictate should be made to show them the true consequences which will result from their conduct, the strong arm of the law, backed, as in such cases it ever will be, by public opinion, should be instantly and unhesitatingly applied, to prevent them from violating the liberty of a portion of their own, or of any other class of society.

285. Amongst the evils which ultimately fall heavy on the working classes themselves, when, through mistaken views, they attempt to interfere with their employers, in the mode of carrying on their business, may be mentioned the removal of factories to other situations, where the proprietors may be free from the improper control of their men. The removal which took place in consequence of the combinations in Nottinghamshire, of a considerable number of lace frames, to the western counties, has already been mentioned. Other instances have occurred, where the injury has been still greater, by the removal of a portion of the skill and capital of the country to a foreign land. Such was the case at Glasgow, as stated in the fifth Report, respecting artizans und machinery. One of the partners in an extensive cotton factory, disgusted by the unprincipled conduct of the workmen, removed to the state of New-York, where he re-established his machinery, and thus afforded, to rivals already formidable to our trade, at once a pattern of our best machinery, and an example of the most economical modes of employing it.

286. One of the remedies employed by the masters against the occurrence of combinations is to make engagements for long periods with the men, and to arrange them in such a manner that they shall not all terminate together. This has been done in some cases at Sheffield, and also in other places.

287. A system of paying the wages of workmen in articles which they consume has been introduced into some of our manufacturing districts, which has been called the "*truck system*." As in many instances it has almost the effect of a combination of the masters against the men, it is a fit subject for discussion in the present chapter. It should, however, be separated from another system of a very different tendency, which will be first described.

The principal necessaries for the support of a workman and his family are few in number, and are usually purchased by him in small quantities weekly. Upon such quantities, sold by the retail dealer, a large profit is generally made; and if the article is one whose quality, like that of tea, is not readily estimated, then a great additional profit is made by the retail dealer selling an inferior article.

In such circumstances, where the number of workmen living on the same spot is large, it may be thought desirable that they should unite together, and have an agent, to purchase wholesale such articles as tea, sugar, bacon, &c. in most demand, and to retail them out at prices which will just repay their wholesale cost, and the expense of the agent they employ. If this be wholly managed by a committee of workmen, aided perhaps by advice of the master, and if the agent is paid in such a manner as to be interested in procuring good and reasonable articles, it may be a benefit to the workmen; and if the plan succeed in reducing the cost of articles of necessity to the men, it is clearly the interest of the master to encourage it. The master may indeed be enabled to afford them facilities in making their wholesale purchases; but he ought never to be in such a position as to have the least interest in the profit made by the articles sold. The men, on the other hand,

who subscribe to set up the shop, ought not, in the slightest degree, to be compelled to make their purchases at it: the goodness and cheapness of the article ought to be their sole inducements.

It may perhaps be objected, that this plan is only employing a portion of the capital belonging to the workmen in a retail trade; and that, without it, competition amongst small shopkeepers will reduce the articles to nearly the same price. Perhaps there would be less reason to have recourse to it, if the objects of consumption required no *verification;* but combining what has been stated on that subject in the preceding pages of this work, on price, with the present argument, the plan seems liable to no serious objections.

288. The *truck system* is quite different in its effects. The master-manufacturer keeps a retail shop for articles in demand by his men, and either pays their wages in goods, or compels them by direct agreement, or incidentally by unfair means, to expend the whole or a certain part of their wages at his shop. If the manufacturer kept this shop merely for the purpose of securing good articles at fair prices to his workmen, and if he offered no inducement to them to purchase at his shop, except the superior cheapness of his articles, it would certainly be advantageous to the men. But, unfortunately, this is not always the case; and the temptation to the master, in times of depression, to reduce in effect the wages which he pays, (by increasing the price of articles at his shop,) without altering the nominal rate of payment, is frequently too great to be withstood. If the object be solely to procure for his workmen better articles, it would be more effectually accomplished by supplying a small capital, at a moderate rate of interest, and allowing the details of the shop to be conducted by a committee of workmen, in conjunction with his own agent, and allowing the books of the shop to be audited monthly by the men.

289. Wherever the workmen are paid in goods, or are compelled to purchase at the master's shop, the evils are very great; much injustice is done to the men, and much misery results from it. Whatever may have been the intentions of the master in such a case, the real effect is to deceive the workman as to the amount he receives in exchange for his labor. Now, the principles on which the happiness of that class of society depends are sufficiently difficult to be thoroughly understood, even by those who are blessed with far better opportunities of investigating them: and the importance of being acquainted with those which relate to themselves, is of more vital consequence to the workman than to many other classes. It is therefore highly desirable to assist them in comprehending those principles, by rendering all the relations in which they stand to each other, and to their employers, as simple as possible. Workmen should be paid entirely in money; their work should be measured by some unbiassed, some unerring piece of mechanism; the time during which they are employed should be definite, and punctually adhered to. The payments they make to their benefit societies should be fixed on such just principles as not to require extraordinary contributions. In short, the object of all who wish to promote their happiness, should be to give them, in the simplest form, the means of knowing before-hand the sum they are likely to acquire by their labor, and the money they will be obliged to expend for their support: thus putting before them, in the clearest light, the certain result of persevering industry.

290. The cruelty which is inflicted on the workman, by the payment of his wages in goods, is often very severe. The little purchases necessary for the comfort of his wife and children, perhaps the medicines he occasionally requires for them in illness, must all be made through the medium of barter, and he is obliged to waste his time in arranging an exchange, in which the goods which he has been compelled to accept for his labor are invariably taken at a lower price than that at which his master charged them to him. The father of the family, perhaps, writhing under the agonies of the tooth-ache, is obliged to make his hasty bargain with the village surgeon, ere he will remove the cause of his pain; or the disconsolate mother is compelled to sacrifice her depreciated goods in exchange for the last receptacle of her departed offspring. The subjoined evidence from the Report of the Committee of the House of Commons on Frame-Work Knitters' Petitions, shows that these are not exaggerated statements:

"It has been so common in our town to pay goods instead of money, that a number of my neighbors have been obliged to pay articles for articles, to pay sugar for drugs out of the druggist's shop; and others have been obliged to pay sugar for drapery goods, and such things, and exchange in that way numbers of times. I was credibly informed that one person paid half a pound of ten-penny sugar and a penny to have a tooth drawn; and there is a credible neighbor of mine told me, that he had heard that the sexton had been paid for digging a grave with sugar and tea; and before I came off, knowing I had to give evidence upon these things, I asked this friend to inquire of the sexton whether this was a fact: the sexton hesitated for a little time, on account of bringing into discredit the person who paid these goods; however, he said at last, 'I have received these articles repeatedly—I know these things have been paid to a great extent in this way.'"

ON COMBINATIONS OF MASTERS AGAINST THE PUBLIC.

291. A species of combination occasionally takes place amongst manufacturers against persons having patents; and these combinations are always injurious to the public, as well as unjust to the inventors. Some years since,

a gentleman invented a machine by which modellings and carvings were cut in mahogany and other fine woods. The machine resembled, in some measure, the drilling apparatus employed in ornamental lathes; it produced beautiful work, at a very moderate expense; but the cabinet-makers met together, and combined against it, and the patent has consequently never been *worked*. A similar fate awaited a machine for cutting veneers by means of a species of knife. In this instance, the wood could be cut thinner than by the circular saw, and no waste of it was incurred; but "the trade" set themselves against it, and, after a heavy expense, it was given up.

Similar examples of combination seem not to be unfrequent, as appears by the Report of the Committee of the House of Commons on Patents for Inventions, June, 1829. See the evidence of Mr. Holdsworth.

292. There occurs another kind of combination against the public, with which it is difficult to deal. It usually ends in a monopoly, and the public are then left to the discretion of the monopolists not to charge them above the "*growling point*"—that is, *not to make them pay so much as to induce them actually to combine against the imposition.* This occurs when two companies supply water or gas to consumers by means of pipes laid down under the pavement in the streets of cities: it may possibly occur also in docks, canals, railroads, &c. and in other cases where the capital required is very large, and the competition very limited. If water or gas companies combine, the public immediately loses all the advantages of competition; and it has generally happened, that, at the end of a period during which they have undersold each other, the several companies have agreed to divide the whole district supplied into two or more portions, and that each company has removed its pipes from all streets but those in its own portion of the district. This removal causes great injury to the pavement, and when the pressure of increased rates induces a new company to start, the same inconvenience is again produced. Perhaps one remedy to evils of this kind might be, when a charter is granted to such companies, to restrict, to a certain amount, the rate of profit to be divided on the shares, and to direct that any profits beyond shall accumulate for the repayment of the original capital. This has been done in several late acts of Parliament, establishing companies. The maximum rate of profit allowed ought to be liberal, to compensate for the risk, and the public ought to have auditors on their part, and the accounts should be annually published, for the purpose of preventing the object of the limitations from being defeated. It must, however, be admitted that this is an interference with capital, which, if allowed, should be examined with great circumspection in each individual case, until some general principle is established on well admitted grounds.

293. An instrument, called a gas-meter, which ascertains the quantity of gas used by each consumer, has been introduced, and furnishes a satisfactory mode of determining the payments to be made by individuals to the gas companies. An instrument somewhat similar in its nature might be contrived for the sale of water; but, in that case, a difficulty is to be apprehended, arising from the diminished quantity which would then run to waste: the streams of water running through the sewers in London are largely supplied from this source; and if the quantity of water flowing through them were diminished, the drainage of the metropolis might be injuriously affected.

294. A powerful combination has long existed amongst the coal owners in the north of England, by which the public has suffered in the payment of increased price. The late examination of evidence before a Committee of the House of Commons has explained its mode of operation, and the Committee have recommended that, for the present, the sale of coal should be left to the competition of other districts.

295. A powerful combination of another kind exists at this moment to a great extent, and operates upon the price of the very pages which are now communicating information respecting it. A subject so interesting to every reader, and still more so to every manufacturer of the article which the reader consumes, deserves an attentive examination.

We have previously shown, (at page 44,) the component parts of the expense of each copy of the present work; and we have seen that the total amount of its cost of production, exclusive of any payment to the author for his labor, is 2*s.* 3¼*d.*

Another fact, with which the reader is more practically familiar, is that he has paid, or is to pay, his bookseller six shillings for the volume. Let us now examine into the distribution of these six shillings, and then, having the facts of the case before us, we shall be better able to judge of the merits of the combination, and to explain its effects.

Distribution of the profits on a six-shilling book:

	Buys at. s. d.	Sells at. s. d.	Profit on capital expended.
No. I. The *Publisher*, who accounts to the author for every copy received,	3 10	4 2	10 pr ct.
No. II. *Bookseller*, who retails to the public, -	4 2	6 0	44 "
——. Or, - - -	4 6	6 0	33⅓ "

No. I, the Publisher, is a bookseller: he is, in fact, the author's agent. His duties are to receive and take charge of the stock, for which he supplies warehouse room; to advise the author about the times and methods of advertising; and to insert the advertisements. As he publishes other books, he will advertise lists of those sold by himself; and thus, by combining many in one advertisement, diminish the expense to each of his principals. He pays the

author only for the books actually sold, consequently he makes no outlay of capital, except that which he pays for advertisements; but he is answerable for any bad debts he may make in disposing of them. His charge is usually ten per cent. on the returns.

No. II is the Bookseller, who retails the work to the public. On the publication of a new book, the publisher sends round to the trade to receive subscriptions from them for any number of copies not less than two. These copies are usually charged to the subscribers, on an average, at about four or five per cent. less than the wholesale price of the book: in the present case they pay 4*s*. 2*d*. for each copy. After the day of publication, the price charged by the publisher to the booksellers is 4*s*. 6*d*. Different publishers offer different terms to the subscriber; and it is usual, after intervals of about six months, for the publisher again to open a subscription list, so that if the work be one for which there is a steady demand, the trade avail themselves of these opportunities of purchasing, at the reduced rate, enough to supply their probable demand.

296. The volume thus purchased of the publisher at 4*s*. 2*d*. or 4*s*. 6*d*. is retailed by the bookseller to the public at 6*s*. In the one case he makes a profit of forty-four, in the other of thirty-three per cent. Even the smaller of these two rates of profit, on the capital employed, certainly appears to be too large. It sometimes happens that when a purchaser inquires for a book, the retail dealer sends across the street to the wholesale agent, and receives for this trifling service one-fourth part of the money the purchaser pays; and perhaps the retail dealer also takes six months credit for the price which the volume actually cost him. It is stated that all retail booksellers allow to their customers a discount of ten per cent. upon orders above 20*s*., and that, therefore, the nominal profit of forty-four or thirty-three per cent. is considerably reduced. If this is the case, it may fairly be inquired why the price of £2, for example, is printed upon the back of a book, when every bookseller is ready to sell it at £1 16*s*.; and why those who are unacquainted with that circumstance should be made to pay more than others who are better informed? Another reason has been assigned for the great profit charged upon books, namely, that the purchasers take long credit. This is probably a fact; and, admitting it, no reasonable person can object to a proportionate increase of price. But, certainly, it is equally clear that gentlemen, who do pay ready money, should not be charged the same price as those who defer their payments to a very remote period. In the country, there is a greater appearance of reason for a considerable allowance between the retail dealer and the public, because the profit of the country bookseller will be diminished by the expense of the conveyance of the books from London; but, even in this case, it appears to be too large when compared with the rate of interest which capital produces in other trades.

297. That the profit in retailing books is really too large is proved by two circumstances: First, That the same nominal rate of profit has existed in the bookselling trade for a long series of years, notwithstanding the great fluctuations in the rate of profit on capital invested in every other business. Secondly, That, until very lately, a multitude of booksellers in all parts of London were willing to be satisfied with a much smaller profit, and to sell, for ready money, or at short credit, to persons of undoubted character, at a profit of only ten per cent., and, in some instances, even at a still smaller per centage, instead of that of twenty-five per cent. on the published prices. It cannot be pretended that this high rate of profit is necessary to cover the risk of the bookseller having some copies left on his shelves, because he need not buy of the publisher a single copy more than he has orders for; and even if he do purchase more at the subscription price, he proves, by that very purchase, that he himself does not estimate that risk at above from four to eight per cent. It should also be remarked, that the publisher is generally a retail, as well as a wholesale, bookseller; and that, besides the profit which he realizes on every copy sold by him in his capacity of agent, he is allowed to charge the author as if every copy had been subscribed for at 4*s*. 2*d*., and of course he receives the same profit as the rest of the trade for those retailed in his shop.

298. Now, a certain number of the London booksellers have combined together. One of their objects is to prevent any bookseller from selling a book at less than ten per cent. under the published price; and in order to enforce this principle, they refuse to sell books, except at the publishing price, to any bookseller who declines signing their agreement. By degrees, many were prevailed upon to join this combination; and the effect of the exclusion it inflicted, left the small capitalist no option between signing or having his business destroyed. Ultimately, nearly the whole trade, comprising about two thousand four hundred persons, have signed the agreement.

As might be naturally expected from an agreement so injurious to many of the parties to it, disputes have arisen: several booksellers have been placed under the ban of the combination, who allege that they have not violated its rules, and who accuse the opposite party of using spies, &c. to entrap them.

299. The origin of this combination has been explained by Mr. Pickering, of Chancery lane, himself a publisher, in a printed statement, entitled "*Booksellers' Monopoly.*"

The following list of booksellers has been copied from that printed at the head of each of the cases published by Mr. Pickering, of the booksellers who form the committee for conducting this combination: J. Allen, 7 Leadenhall street—J. Arch, 61 Cornhill—R. Baldwin,

47 Paternoster row—J. Booth—J. Duncan, 37 Paternoster row—J. Hatchard, Piccadilly—R. Marshall, Stationers' Court—J. Murray, Albemarle street—O. Rees, 39 Paternoster row—J. M. Richardson, 23 Cornhill—J. Rivington, St. Paul's Church-yard—E. Wilson, Royal Exchange.

300. In whatever manner the profits are divided between the publisher and the retail bookseller, the fact remains, that the reader has paid for the volume in his hands 6*s*., and that the author will receive only 3*s*. 10*d*., out of which latter sum the expense of printing the volume must be paid: so that in passing through two hands this book has produced a profit of forty-four per cent. This excessive rate of profit has drawn into the book trade a larger share of capital than was really advantageous; and the competition between the different portions of that capital has naturally led to the system of underselling, to which the committee above-mentioned are endeavoring to put a stop.*

There are two parties who chiefly suffer from this combination—the public and authors. The first party can seldom be induced to take an active part against any grievance; and, in fact, little is required from it, except a cordial support of the authors, in any attempt to destroy a combination so injurious to the interests of both. Many an industrious bookseller would be glad to sell for 5*s*. the volume which the reader holds in his hand, and for which he has paid 6*s*.; and, in doing so for *ready money*, the tradesman who paid 4*s*. 6*d*. for the book would realize, without the least risk, a profit of eleven per cent. on the money he had advanced. It is one of the objects of the combination we are discussing, to prevent the small capitalist from employing his capital at that rate of profit which he thinks most advantageous to himself; and such a proceeding is decidedly injurious to the public.

301. Having derived little pecuniary advantage from my own literary productions, and being aware that, from the very nature of their subjects, they can scarcely be expected to reimburse the expense of preparing them, I may be permitted to offer an opinion, which I believe to be as little influenced by any expectation of advantage from the future as it is by any disappointment at the past. Before, however, we begin to sketch the plan of a campaign against Paternoster row, it will be fit to inform the reader of the nature of the enemy's forces, and of his means of attack and defence. Several of the great publishers find it convenient to be the proprietors of Reviews, Magazines, Journals, and even of Newspapers. The *Editors* are paid, in some instances very handsomely, for their superintendance; and it is scarcely to be expected that they should always mete out the severest justice on works by the sale of which their employers are enriched. The great and popular works of the day are of course reviewed with some care, and with deference to public opinion. Without this, the journals would not sell; and it is convenient to be able to quote such articles as instances of impartiality. Under shelter of this, a host of ephemeral productions are written into a transitory popularity; and by the aid of this process, the shelves of the booksellers, as well as the pockets of the public, are disencumbered. To such an extent are these means employed, that some of the periodical publications of the day ought to be regarded merely as *advertising machines*. That the reader may be in some measure on his guard against such modes of influencing his judgment, he should examine whether the work reviewed is published by the bookseller who is the proprietor of the review: a fact which can sometimes be ascertained from the title of the book as given at the head of the article. But this is by no means a certain criterion, because partnerships in various publications exist between houses in the book trade, which are not generally known to the public: so that, in fact, until Reviews are established in which booksellers have no interest, they can never be safely trusted.

302. In order to put down the combination of booksellers, no plan appears so likely to succeed as a counter-association of authors. If any considerable portion of the literary world were to unite and form such an association, and if its affairs were directed by an active committee, much might be accomplished. The objects of this union should be to employ some person well skilled in the printing, and in the bookselling trade; and to establish him in some central situation as their agent. Each member of the association to be at liberty to place any, or all of his works, in the hands of this agent for sale; to allow any advertisements, or lists of books published by members of the association, to be stitched up at the end of each of his own productions: the expense of preparing them being defrayed by the proprietors of the books advertised. The duties of the agent would be to retail to the public, for *ready money*, copies of books published by members of the association; to sell to the trade at prices agreed upon any copies they may require; to cause to be inserted in the journals, or at the end of works published by members, any advertisements which the committee or authors may direct; to prepare a general catalogue of the works of members; to be the agent for any member of the association in treating respecting the printing of any work. Such a union would naturally present other advantages; and as each author would retain the liberty of putting any price he might think fit on his productions, the public would still have the advantage of reduction in price produced by competition between authors on the same subject, as well as

* The Monopoly Cases, Nos. 1, 2, and 3, of those published by Mr. Pickering, should be consulted; and, as the public will be better able to form a judgment by hearing the other side of the question, perhaps the Chairman of the Committee (Mr. Richardson) would print those Regulations respecting the trade, —a copy of which, Mr. Pickering states, is refused by the *Committee even to those who sign them.*

of that arising from a cheaper mode of publishing the volumes sold to them.

303. Possibly one of the consequences resulting from such an association would be the establishment of a good and an impartial Review, a work whose want has been felt for several years. The two long established and celebrated Reviews, the unbending champions of the most opposite political opinions, are, from widely differing causes, exhibiting unequivocal signs of decrepitude and decay. The Quarterly advocate of despotic principles is fast receding from the advancing intelligence of the age; and the new strength and new position which that intelligence has acquired for itself demands for its expression new organs, equally the representatives of intellectual power and of its moral energies; whilst, on the other hand, the sceptre of its Northern rival has passed from the vigorous grasp of those who established its dominion into feebler hands.

A difficulty has been stated that those most competent to supply periodical criticism are already engaged. But it is to be observed that there are many who now supply literary criticisms to journals whose political principles they disapprove; and that if once a respectable and well supported Review* were established, capable of competing, in payment to its contributors, with the wealthiest of its rivals, it would very soon be supplied with the best materials the country can produce.†

ON THE EFFECT OF TAXES AND OF LEGAL RESTRICTIONS UPON MANUFACTURES.

304. As soon as a tax is put upon any article, the ingenuity of those who make, and of those who use it, is directed to the means of evading as large a part of that tax as they can; and this may often be accomplished in ways that are perfectly fair and legal. An excise duty exists at present of 3*d.*‡ per pound upon all writing paper. The effect of this impost is that much of the paper which is employed is made extremely thin, in order that the weight of a given number of sheets may be as small as possible. Soon after the first imposition of the tax upon windows, which depended upon their number, and not upon their size, new-built houses began to have fewer windows and of a larger size than before. Staircases were lighted by extremely long windows, illuminating three or four flights of stairs. When the tax was increased, and the *size* of windows charged as single was limited, then still greater care was taken to have as few windows as possible, and internal lights became frequent. These internal lights in their turn became the subject of taxation; but it was easy to evade the discovery of them, and in the last act of Parliament, reducing the assessed taxes, they ceased to be chargeable. From the changes thus successively introduced in the number, the forms, and the positions of the windows, a tolerable guess might in some instances be formed of the age of a house.

305. The effects of regulations of excise upon our home manufactures are often productive of inconvenience, and check in some measure the natural progress of improvement. It is frequently necessary, for the purposes of revenue, to oblige manufacturers to take out a license, and to compel them to work according to certain rules, and to make stated quantities at each operation. When these quantities are large, as they usually are, they deter manufacturers from making experiments upon new materials: they likewise prevent them from discovering, by trial, improved methods of conducting their processes. Difficulties of this nature have occurred in experimenting upon glass for optical purposes; and in this case, permission has been obtained by fit persons to make the experiments, without the interference of the excise. It ought, however, to be remembered, that such permission, if frequently granted, might be abused; and that the greatest protection against such an abuse will be found in bringing the force of public opinion to bear upon scientific men; and thus enabling the proper authorities, although themselves but moderately conversant with science, to judge of the propriety of the permission, by the public character of the applicant.

306. From the evidence given, in 1808, before the Committee of the House of Commons, on *Distillation from Sugar and Molasses*, it appeared that, by a different mode of working from that prescribed by the Excise, the spirits from a given weight of corn, which then produced eighteen gallons, might easily have been increased to twenty gallons. Nothing more was required than to make what is called the *wash* weaker: the consequence of which is that fermentation goes on to a greater extent. It was stated, however, that such a deviation would render the collection of the duty liable to great difficulties; and that it would not benefit the distiller much, since his price was enhanced to the customer by any increase of expense in the fabrication. Here then was an instance in which a quantity, amounting to one-ninth of the total produce, was actually lost to the country. A similar effect arises in the coal trade, from the effect of a duty, for, according to the evidence before the House of Commons, it appears that a considerable quantity of the very best coal is actually wasted. The amount of waste is very various in different mines, but in some cases it amounts to one-third.

307. The effects of duties upon the import of

* At the moment when this opinion as to the necessity for a new Review was passing through the press, I was informed that the elements of such an undertaking were already organized.

† It has been suggested to me, that the doctrines maintained in this chapter may subject the present volume to the opposition of that combination which it has opposed. I do not entertain that opinion; and for this reason, that the booksellers are too shrewd a class to supply such an admirable passport to publicity. But should my readers take a different view of the question, they can easily assist in remedying the evil, by each mentioning the existence of this little volume to two of his friends.

‡ Twenty-eight shillings per cwt. for the finer, twenty-one shillings per cwt. for the coarser papers.

foreign manufactures are equally curious. A singular instance occurred in the article *bar iron*, which was liable to a duty of 140 per cent. ad valorem, on introduction into the United States, whilst that upon *hardware* was 25 per cent. In consequence of this tax, large quantities of malleable iron rails for railroads were imported into America under the denomination of hardware; and the difference of 115 per cent. in duty more than counter-balanced the expense of fashioning the iron into rails prior to its importation.

308. Duties, drawbacks, and bounties, when considerable in amount, are all liable to objections of a very serious nature, from the frauds to which they give rise. It has been stated before Committees of the House of Commons, that calicoes, made up in the form and with the appearance of linen, have frequently been exported for the purpose of obtaining the bounty. The calico made up in this way sells at 1*s.* 4*d.* per yard, whereas linen of equal fineness is worth from 2*s.* 8*d.* to 2*s.* 10*d.* per yard. It appeared from the evidence that one house in six months sold five hundred such pieces.

In all cases heavy duties, or prohibitions, are ineffective, as well as injurious: for unless the articles excluded are of very large dimensions, there constantly arises a price at which they will be clandestinely imported by the smuggler. The extent, therefore, to which smuggling can be carried should always be considered in the imposition of new duties, or in the alteration of old ones. Unfortunately, it has been pushed so far, and is so systematically conducted, that the price per cent. at which most contraband articles can be procured from France is well known. From the evidence of Mr. Galloway, it appears that from 30 to 40 per cent. was the rate of insurance on exporting prohibited machinery from England, and that the larger the quantity the less was the per centage demanded.

309. In examining into the effect produced, or to be apprehended, from any particular mode of taxation, it is necessary to inquire a little into the interests of the parties who approve of the plan in question, as well as those who object to it. Instances have occurred where the persons paying a tax into the hands of government have themselves objected to any reduction. This happened in the case of one class of calico printers, whose interest was injured by a removal of the tax on the printing. They received from the manufacturers payment for the duty about two months before they were called on to repay it to government: the consequence was that a considerable capital always remained in their hands. The evidence which states this circumstance is well calculated to promote a reasonable circumspection in such inquiries.

"Do you happen to know any thing of an opposition from calico printers to the repeal of the tax on printed calicoes?

"I have certainly heard of such an opposition, and I am not surprized at it. There are a very few individuals who are, in fact, interested in the non-repeal of the tax. There are two classes of calico printers: one, who print their own cloth, send their goods into the market, and sell them on their own account; they frequently advance the duty to government, and pay it in cash before their goods are sold, but generally before the goods are paid for, being most commonly sold on a credit of six months; they are of course interested on that account, as well as on others that have been stated, in the repeal of the tax. The other class of calico printers print the cloth of other people: they print for hire, and on re-delivery of the cloth, when printed, they receive the amount of the duty, which they are not called upon to pay to government sooner, on an average, than nine weeks from the stamping of the goods. Where the business is carried on upon a large scale, the arrears of duty due to government often amount to eight, or even ten thousand pounds, and furnish a capital with which these gentlemen carry on their business; it is not, therefore, to be wondered at that they should be opposed to the prayer of our petition."

310. The policy of giving bounties, and of enforcing restrictions against foreign articles, which can be produced more cheaply in other countries, is of a very questionable nature: and, except for the purpose of introducing a new manufacture in a country where there is not much commercial or manufacturing spirit, is scarcely to be defended. All incidental modes of taxing one class of the community, the consumers, to an unknown extent, for the sake of supporting another class, the manufacturers, who would otherwise abandon that mode of employing their capital, are highly objectionable. One part of the price of any article which is so produced consists of the expenditure, together with the ordinary profits of capital: the other part of its price may be looked upon as charity, given to induce the manufacturer to continue an unprofitable use of his capital, in order to give employment to his workmen. Now, in many instances, if the actual amount of the latter part of the price were known, the extent of the payment made by consumers, on account of restrictions only, would astonish *even those who advocate them;* and it would be evident to both parties, that the employment of capital in that particular trade ought to be abandoned.

311. The restriction of articles produced in a manufactory to certain sizes is attended with an economical effect. This arises chiefly from the smaller number of different tools required in making them, as well as from less frequent change in the adjustment of those tools. A similar economy prevails in the navy, by having ships divided into a certain number of classes, each of which comprises vessels of the same dimensions: the rigging made for one vessel will fit any other of its class.

312. The effects of the removal of a monopoly are often very important, and they were perhaps never more remarkable than in the bobbin-net trade, in the years 1824 and 1825.

These effects were, however, considerably enhanced by the general rage for speculations which was so prevalent during that singular period. One of the patents of Mr. Heathcote for a bobbin-net machine had expired, whilst another, for an improvement in a particular part of such machines, called a *turn-again*, had yet a few years to run. Many licenses had been granted to use the former patent, which were charged at the rate of about five pounds per annum for each quarter of a yard in width, so that what is termed a *six-quarter frame*, (which makes bobbin-net a yard and a half wide,) paid thirty pounds a year. The second patent was ultimately abandoned in August, 1823, infringements of it having taken place.

The bobbin-net machine occupies little space, and is, from that circumstance, well adapted for a domestic manufacture. It had also hitherto yielded a very large profit: it was therefore not surprizing that, on the removal of the monopoly arising from this patent, a multitude of persons became desirous of embarking in the trade. The machines which already existed were principally in the hands of the manufacturers; but a kind of mania for obtaining them seized on persons of all descriptions, who could raise a small capital; and, under its influence, butchers, bakers, small farmers, publicans, gentlemen's servants, and, in some cases, even clergymen, became anxious to possess bobbin-net machines.

Some few machines were rented; but in most of these cases the workman purchased the machine he employed, by instalments of from 3 to £6 weekly, for a six-quarter machine; and many individuals, unacquainted with the mode of using the machines so purchased, paid others of more experience for instructing them in their use—50 or £60 being sometimes given for this instruction. The success of the first speculators induced others to follow the example; and the machine-makers were almost overwhelmed with orders for lace-frames. Such was the desire to procure them, that many persons deposited a large part, or the whole of the price, in the hands of the frame-makers, in order to insure their having the earliest supply. This, as might naturally be expected, raised the price of wages amongst the workmen employed in machine-making: and the effect was felt at a considerable distance from Nottingham, which was the centre of this mania. Smiths not used to *flat filing*, coming from distant parts, earned from 30 to 42*s*. per week; finishing smiths, accustomed to the work, gained from 3 to £4 per week; the forging smith, if accustomed to his work, gained from 5 to £6 per week, and some few earned £10 per week. In making what are technically called *insides*, those who were best paid were generally clock and watch makers, from all the districts round, who received from 3 to £4 per week. The *setters-up* persons, who put the parts of the machine together, charged £20 for their assistance; and a six-quarter machine could be put together in a fortnight or three weeks. Good workmen, being thus induced to desert less profitable branches of their business, in order to supply this extraordinary demand, the masters, in other trades, soon found their men leaving them, without being aware of the immediate reason: some of the more intelligent, however, ascertained the cause, and went from Birmingham to Nottingham, in order to examine into the circumstances which had withdrawn almost all the journeymen clock-makers from their own workshops. It was soon apparent that the men who had been making clocks at Birmingham, at the rate of 25*s*. a week, could earn £2 by working at lace-frame making at Nottingham.

On examining the nature of this profitable work, the clock-makers perceived that one part of the bobbin-net machines, that which held the bobbins, could be easily made in their own workshops. They therefore contracted with the machine-makers, who had already more work ordered than they could execute, to supply the *bobbin-carriers*, at a price which enabled them, on their return home, to give such increased wages as should retain their own workmen, as well as yield themselves a good profit. Thus an additional facility was afforded for the construction of these bobbin-net machines. The conclusion was not difficult to be foreseen: the immense supply of bobbin-net thus poured into the market speedily reduced its price. This reduction in price rendered the machines by which the net was made less valuable: some few of the earlier producers for a short time carried on a profitable trade, but multitudes were disappointed, and many ruined. The low price at which the fabric sold, together with its lightness and beauty, combined to extend the sale; and ultimately, new improvements in the machines rendered the older ones still less valuable.

313. The bobbin-net trade is at present both extensive and increasing; and, as it may probably, at some future time, claim a larger portion of public attention, it will be interesting to describe briefly its actual state.

A lace-frame, *at the present day*, on the most improved principle, manufacturing a piece of net two yards wide, when worked night and day, will produce six hundred and twenty *racks* per week. A *rack* is two hundred and forty holes; and, as in the machine to which we refer, three *racks* are equal in length to one yard, it will produce twenty-one thousand four hundred and ninety-three square yards of bobbin-net annually. Three men kept this machine constantly working, and they were paid by piece-work about 25*s*. each per week in 1830. Two boys, working only in the day-time, can prepare the bobbin for this machine, and are paid from 2 to 4*s*. per week, according to their skill. Forty-six square yards of this net weigh two pounds three ounces: so that each square yard weighs a little more than three quarters of an ounce.

For a condensed and general view of the present state of this trade, we shall avail ourselves of a statement by Mr. William Felkin, of Nottingham, entitled "Facts and Calculations illustrative of the Present State of the Bobbin-net Trade," dated September, 1831. It appears to have been collected with care, and contains, in a single sheet of paper, a body of facts of the greatest importance.*

314. The total capital employed in the factories, for preparing the cotton, in those for weaving the bobbin-net, and in various processes to which it is subject, is estimated at above two millions of pounds, and the number of persons who receive wages at above two hundred thousand.

"Comparison of the value of the raw material imported, with the value of the goods manufactured therefrom:

"Amount of Sea Island cotton annually used, 1,600,000 lbs., value £120,000: this is manufactured into yarn, weighing 1,000,000 lbs., value £500,000.

"There is also used 25,000 lbs. of raw silk, which cost £30,000, and is doubled into 20,000 lbs. thrown, worth £40,000.

Raw Material.	Manufacture.	Sq'e yards produced.	Value pr sq. yard. s. d.	Total Value.
Cotton, 1,600,000 lbs.	Power Net	6,750,000	1 2	421,875†
	Hand do.	15,750,000	1 9	1,378,125‡
	Fancy do	150,000	3 6	26,250
Silk, 25,000 lbs.	Silk Goods	750,000	1 9	65,625
		23,400,000		1,891,875

"The brown nets which are sold in the Nottingham market are in part disposed of by the agents of twelve or fifteen of the larger makers, that is, to the amount of about £250,000 a year. The principal part of the remainder, that is, about £1,050,000 a year, is sold by about two hundred agents, who take the goods from one warehouse to another for sale.

"Of this production, about half is exported in the unembroidered state, and in the white principally; yet a large quantity is sent in the unbleached state, and is embroidered abroad, and much is figured in the white on the continent: so that it is probable that as much is figured abroad as at home, and this principally on account of wages being lower there than here, notwithstanding the low rate of embroiderers' earnings in this country. This foreign embroidery is chiefly done in Belgium, Saxony, and, until recently, Poland. The exports of bobbin-net are in great part to Hamburgh, for sale at home and at Leipzic and Frankfort fairs, Antwerp, and the rest of Belgium; to France, by contraband; to Italy, and North and South America. Though a very suitable article, yet the quantity sent eastward of the Cape of Good Hope has hitherto been too trifling for notice. Three-eighths of the whole production are sold unembroidered at home. The remaining one-eighth is embroidered in this country, and increases the ultimate value as under, viz.:

Embroidery.	Increases value.	Ultimate worth.
On power net, - - - -	£ 131,840	£553,715
On hand net, - - - -	1,205,860	2,583,985
On fancy net, - - - -	78,750	105,000
On silk net, - - - - -	109,375	175,000
Total embroidery, wages, and profit,	£1,525,825	
Ultimate total value, - - - - -		£3,417,700

"From this it appears that, in the operations of this trade, which had no existence twenty years ago, £120,000 original cost of cotton becomes, when manufactured, of the ultimate value of £3,242,700 sterling.

"There are about seventy houses engaged chiefly in embroidering goods, and about seventy houses engaged in the preparation and sale of plain goods principally. The cash paid to small owners, for the purchase of hand nets, about equals the amount of capital created by the credit given in this market by the power net manufacturers.

"As to weekly wages paid, I hazard the following as the judgment of those conversant with the respective branches, viz.:

"In fine spinning and doubling—adults, 25*s.*; children, 7*s.*; work, 12 hours per day. In bobbin-net making—men working machines, 18*s.*; apprentices, youths of fifteen, or more, 10*s.*; by power, 15 hours; by hand, 8 to 12 hours, according to width. In mending—children, 4*s.*; women, 8*s.*; work, 9 to 14 hours, *ad libitum.* In winding, threading, &c.—children and young women, 5*s.*; irregular work, according to the progress of machines. In embroidery—children seven years old and upwards, 1 to 3*s.*; work, 10 to 12 hours; women, if regularly at work, 5*s.* to 7*s.* 6*d.*; 12 to 14 hours.

"As an example of the effect of the wages of lace embroidery, &c. it may be observed, it is often the case that a stocking weaver in a country village will earn only 7*s.* a week, and his wife and children 7*s.* to 14*s.* more at the embroidery frame."

§ 315. The principal part of the hand-machines employed in the bobbin-net manufacture are worked in shops forming part of or attached to private houses. The subjoined list will show the kinds of machinery employed, and classes of persons to whom it belongs.

Bobbin-net Machinery now at work in the Kingdom:

Hand Levers—six-quarter, 500; seven-quarter, 200; eight-quarter, 300; ten-quarter, 300; twelve-quarter, 30; sixteen-quarter, 20; twenty-quarter, 1. Total, 1,351.

Hand Rotary—ten-quarter, 50; twelve-quarter, 50. Total, 100.

Hand Circulars—six-quarter, 100; seven-quarter, 300; eight-quarter, 400; nine-quarter,

* I cannot omit the opportunity of expressing my hope that this example will be followed by other trades, since by such means we shall obtain a body of information equally important to the workman, the capitalist, the philosopher, and the statesman.

† Being on an average "coarse 11-point," and nearly all in plain net.

‡ Being on an average "fine 11-point," and two-thirds in "quillings."

100; ten-quarter, 300; twelve-quarter, 100. Total, 1300.

Hand Traverser, Pusher, Straight Bolt, &c. averaging five-quarters, 750.

Total, hand machines, 3501.

Power—six-quarter, 100; seven-quarter, 40; eight-quarter, 350; ten-quarter, 270; twelve-quarter, 220; sixteen-quarter, 20. Total, power machines, 4000.

Total number of Machines, 4501.

700 persons own, each, 1 machine; 226, 2 do.; 181, 3 do.; 96, 4 do.; 40, 5 do.; 21, 6 do.; 17, 7 do.; 19, 8 do.; 17, 9 do.; 12, 10 do.; 8, 11 do.; 6, 12 do.; 5, 13 do.; 5, 14 do.; 4, 16 do.; and 25 own 1192, or respectively 18, 19, 20, 21, 23, 24, 25, 26, 27, 28, 29, 30, 32, 33, 35, 36, 37, 50, 60, 68, 70, 75, 95, 105, 206. Total number of owners, 1382, holding together 4500 machines.

The hand workmen consist of the above named owners, 1000; and of journeymen and apprentices, 4000. Total, 5000.

These machines are distributed as follows:—Nottingham, 1240; New Radford, 140; Old Radford and Bloomsgrove, 240; Ison Green, 160; Beeston and Chilwell, 130; New and Old Snenton, 180; Derby and its vicinity, 185; Loughborough and its vicinity, 385; Leicester, 95; Mansfield, 85; Tiverton, 220; Barnstable, 180; Chard, 190; Isle of Wight, 80; in sundry other places, 990. Total, 4500.

"Of the above owners, one thousand work in their own machines, and enter into the class of journeymen as well as that of masters in operating on the rate of wages. If they reduce the price of their goods in the market, they reduce their own wages first; and, of course, eventually the rate of wages throughout the trade. It is a very lamentable fact, that one-half, or more, of the one thousand one hundred persons specified in the list as owning one, two, and three machines, have been compelled to mortgage their machines for more than their worth in the market, and are in many cases totally insolvent. This has chiefly arisen from the fall in prices of nets beyond the reduction in the prices of cotton and wages. This class of persons having become indebted to the cotton merchant, have been compelled to pay a comparatively excessive price for the thread they have used, and to sell their goods at the lowest prices of the market. Besides, their machines are principally narrow, and making short pieces, while the absurd system of bleaching, at so much a piece, goods of all lengths and widths, and dressing at so much all widths, has caused the new machines to be all wide, and capable of producing long pieces; of course to the serious disadvantage, if not utter ruin, of the small owner of narrow machines.

It has been observed above, that wages have been reduced, say 25 per cent. in the last two years, or from 24*s.* to 18*s.* a week. Machines have increased in the same time one-eighth in number, or from four thousand to four thousand five hundred, and one-sixth in capacity of production. It is deserving the serious notice of all proprietors of existing machines, that machines are now introducing into the trade of such power of production as must still, more than ever, depreciate (in the absence of an immensely increased demand) the value of their property, have a direct tendency to sink the small owners into journeymen, and either greatly increase the labor, or depreciate the workman's wages. It is a curious fact, as illustrative of the progress of machinery, that there are bobbin-net machines, which being worked by three men, six hours each, or eighteen hours per day, are turning off twenty thousand square yards of good net per annum. Now, it is not to be fairly denied, that such machines being multiplied to some extent, must, with only the actual demand, lower even the present trifling value of the sixteen hundred or seventeen hundred narrow hand-machines, one-half or more, and reduce the rate of wages of those who work in them one-third, and that of the remaining hand-machine workmen at least one-fourth; or, which is the same thing, compel them to increase their labor in the same proportion.

316. From this abstract, we may form some judgment of the importance of the bobbin-net trade. But the extent to which it bids fair to be carried in future, when the eastern markets shall be more open to our industry, may be conjectured from the fact which Mr. Felkin subsequently states, that "We can export a durable and elegant article in cotton bobbin-net, at 4*d.* per square yard, proper for certain useful and ornamental purposes, as curtains, &c.; and another article used for many purposes in female dress at 6*d.* the square yard."

317. *Of Patents.*—In order to encourage the importation, the improvement, or the invention of machines, and discoveries relating to manufactures, it has been the practice in many countries to grant, to the first introducers, an exclusive privilege for a term of years. Such monopolies are termed Patents; and they are granted, on the payment of certain fees, for different periods, from five to twenty years.

The following table, compiled from the report of the Committee of the House of Commons "*On Patents,*" 1829, shows the expense and duration of patents in various countries:

Countries.	Expense. £	s.	d.	Term of Years	Number granted in 6 years, end'g 1826–*Rep.* p. 243.
England - - -	120	0	0	14	914
Ireland - - - -	125	0	0	14	..
Scotland - - -	100	0	0	14	..
America - - -	6	15	0	14	..
France - - - -	12	0	0	5	1091
	32	0	0	10	
	60	0	0	15	
Netherlands - -	£6 to £30			5, 10, 15	..
Austria - - - -	42	10	0	15	1099
Spain*—Inventor	20	9	4	15	..
" Improver	12	5	7	10	..
" Importer	10	4	8	6	..

* The expense of a patent in Spain is stated in the Report to be respectively 2000, 1200, and 1000 reals. If these are reals of

318. It is clearly of importance to preserve to each inventor the sole use of his invention, until he shall have been amply repaid for the risk and expense to which he has been exposed, as well as for the talent he has exerted. But the varieties in the degree of merit are so numerous, and the difficulties of legislating upon the subject are so great, that it has been found almost impossible to frame a law which shall not, practically, be open to the most serious objections.

The difficulty of defending an English patent in any judicial trial is very great; and the number of instances on record in which the defence has succeeded, are comparatively few. This circumstance has induced some manufacturers no longer to regard a patent as a privilege by which a monopoly price may be secured; but they sell the patent article at such a price as will merely produce the ordinary profits of capital, and thus secure to themselves the fabrication of it, because no competitors can derive a profit from evading a patent so exercised.

319. The law of copyright is, in some measure, allied to that of patents; and it is curious to observe, that those species of property which require the highest talent, and the greatest cultivation—which are, more than any other, the pure creations of mind,—should have been the latest to be recognized by the state. Fortunately, the means of deciding on an infringement of property in regard to a literary production, are not by any means difficult; but the present law is, in some cases, productive of considerable hardship, as well as impediment to the advancement of knowledge.

320. Whilst discussing the general expediency of limitations and restrictions, it may be desirable to point out one which seems to promise advantage, although it is by no means free from grave objections. The question of permitting by law, partnerships, in which the responsibility of one or more of the partners is limited in amount, is peculiarly important in a manufacturing, as well as a commercial point of view. In the former light, it appears calculated to aid that division of labor, which we have already proved to be as advantageous in mental as it is in bodily operation; and it might possibly give rise to a more advantageous distribution of talent, and its combinations, than at present exists. There are in this country many persons possessed of moderate capital, not themselves enjoying the power of invention in the mechanical and chemical arts, but who are tolerable judges of such inventions, and who are also excellent judges of human character. Such persons might, with great success, employ themselves in finding out inventive workmen, whose want of capital prevents them from realizing their projects. If they could enter into a limited partnership with persons so circumstanced, they might restrain within proper bounds the imagination of the inventor, and by supplying capital to judicious schemes, render a service to the country, and secure a profit for themselves.

321. Amongst the restrictions intended for the general benefit of our manufactures, there existed one by which workmen were forbidden to go out of the country. A law so completely at variance with every principle of liberty ought never to have been enacted. It was not, however, until experience had convinced the legislature of its inefficiency, that it was repealed. When, after the last war, the renewed intercourse between England and the continent became extensive, it was soon found that it was impossible to discover the various disguises which the workmen could assume; and the effect of the law was rather, by the fear of punishment, to deter those who had left the country from returning, than to check their disposition to migrate.

ON THE EXPORTATION OF MACHINERY.

322. A few years only have elapsed since our workmen were not merely prohibited by act of Parliament from transporting themselves to countries in which their industry would produce for them higher wages, but it was forbidden to export the greater part of the machinery which they were employed to manufacture at home. The reason assigned for this prohibition was the apprehension that foreigners might avail themselves of our improved machinery, and thus compete with our manufacturers. It was, in fact, a sacrifice of the interests of one class of persons, the makers of machinery, for that of another class, those who use it. Now, independently of the impolicy of interfering unnecessarily between these two classes, it may be observed, that the first class, or the makers of machinery, are, as a body, far more intelligent than those who only use it; and although, at present, they are not nearly so numerous, yet, when the removal of the prohibition which cramps their ingenuity shall have had time to operate, there appears good reason to believe that their numbers will be greatly increased; and that it may, in time, surpass that of those who use machinery.

323. The advocates of these prohibitions seem to rely greatly upon the possibility of preventing the knowledge of new contrivances being conveyed from one country to another; and they appear to take much too limited a view of the possible, and even probable, improvements in mechanics. For the purpose of examining the question, let us consider the case of two manufacturers of the same article, one situated in a country in which labor is very cheap, the machinery bad, and the modes of transport slow and expensive; the other engaged in manufacturing in a country in which the price of labor is very high, the machinery excellent, and the means of transport expeditious and economical. Let them both send their produce to the same

Vellon, in which accounts are usually kept at Madrid, the above sums are correct; but if they are reals of *Plate*, the above sums ought to be nearly doubled.

market, and let each receive such a price as shall give to him the profit ordinarily produced by capital in his own country. It is almost certain that in such circumstances the first improvement in machinery will occur in the country which is most advanced in civilization; because, even admitting that the ingenuity to contrive were the same in the two countries, the means of execution are very different. The effect of improved machinery in the rich country will be perceived in the common market, by a small fall in the price of the manufactured article. This will be the first intimation to the manufacturer of the poor country, who will endeavor to meet the diminution in the selling price of his article by increased industry and economy in his factory; but he will soon find that this remedy is temporary, and that the market price continues to fall. He will thus be induced to examine the rival fabric, in order to detect from its structure any improved mode of making it. If, as would most usually happen, he should be unsuccessful in this attempt, he will be forced to endeavor to contrive some improvement in his machinery, or to acquire information respecting that which has taken place in the factories of the richer country. Perhaps, after an ineffectual attempt to attain by letters the information he requires, he sets out to visit the factories of his rivals. To a foreigner and rival manufacturer such establishments are not easily accessible; and the more recent the improvement, the less likely he will be to gain access to them. His next step, therefore, will be to obtain the knowledge he is in search of from the workmen employed in using or making the machines. Without *drawings*, or an examination of the *machines* themselves, this process will be slow and tedious; and he will be liable after all to be deceived by artful and designing workmen, and be exposed to many chances of failure. But suppose he returns to his own country with perfect drawings and instructions, he must then begin to construct his improved machines: and these he cannot execute either so cheaply or so well as his rivals in the richer country; but after the lapse of some time, we shall suppose them to be completed and in working order.

Let us now consider what will have occurred to the manufacturer in the rich country. He will, in the first instance, have realized a profit by supplying the home market, at the usual price, with an article which it costs him less to produce; he will then reduce the price both in the home and foreign market, in order to produce a more extended sale. It is in this stage that the manufacturer in the poor country first feels the effect of the competition; and if we suppose that, from the first application of the new improvement in the rich country, and the commencement of its employment in the poor country, only two or three years elapse, yet will the manufacturer who contrived the improvement, even supposing that during the whole of this time he has made only one step, have realized so large a portion of the outlay which it rendered necessary, that he will now be in a state to make a much greater reduction in the price of his produce, and thus render the gains of his rivals quite inferior to those which his own ingenuity has produced for himself.

324. It is contended, that, by admitting the exportation of machinery, foreign manufacturers will be supplied with machines equal to our own. Now, the first answer to this argument which presents itself is supplied by almost the whole of the present volume, viz.: *That in order to succeed in a manufacture, it is necessary not merely to possess good machinery, but that the domestic economy of the factory should be most carefully regulated.*

The truth, as well as the importance of this principle, is so well established in the Report of a Committee of the House of Commons, "On the Export of Tools and Machinery," that I shall avail myself of the opinions and evidence there stated, before I offer any observations of my own:

"Supposing, indeed, that the same machinery which is used in England could be obtained on the continent, it is the opinion of some of the most intelligent of the witnesses that a want of arrangement in foreign manufactories, of division of labor in their work, of skill and perseverance in their workmen, and of enterprize in the masters, together with the comparatively low estimation in which the master-manufacturers are held on the continent, and with the comparative want of capital, and of many other advantageous circumstances detailed in the evidence, would prevent foreigners from interfering in any great degree by competition with our principal manufacturers; on which subject the committee submit the following evidence as worthy the attention of the House:

'I would ask whether, upon the whole, you consider any danger likely to arise to our manufactures from competition, even if the French were supplied with machinery equally good and cheap as our own?—They will always be behind us until their general habits approximate to ours; and they must be behind us for many reasons that I have before given.

'Why must they be behind us?—One other reason is, that a cotton manufacturer, who left Manchester seven years ago, would be driven out of the market by the men who are now living in it, provided his knowledge had not kept pace with those who have been, during that time, constantly profiting by the progressive improvements that have taken place in that period: this progressive knowledge and experience is our great power and advantage.'

"It should also be observed, that the constant, nay, almost daily, improvements which take place in our machinery itself, as well as in the mode of its application, require that all those means and advantages alluded to above should be in constant operation; and that, in the opinion of several of the witnesses, although

Europe were possessed of every tool now used in the United Kingdom, along with the assistance of English artisans, which she may have in any number, yet, from the natural and acquired advantages possessed by this country, the manufacturers of the United Kingdom would for ages continue to retain the superiority they now enjoy. It is, indeed, the opinion of many that, if the exportation of machinery were permitted, the exportation would often consist of those tools and machines, which, although already superseded by new inventions, still continue to be employed, from want of opportunity to get rid of them—to the detriment, in many instances, of the trade and manufactures of the country; and it is matter worthy of consideration, and fully borne out by the evidence, that by such increased foreign demand for machinery, the ingenuity and skill of our workmen would have greater scope; and that, important as the improvements in machinery have lately been, they might, under such circumstances, be fairly expected to increase to a degree beyond all precedent.

"The many important facilities for the construction of machines and the manufacturing of commodities which we possess, are enjoyed by no other country; nor is it likely that any country can enjoy them to an equal extent for an indefinite period. *It is admitted by every one that our skill is unrivalled; the industry and power of our people unequalled; their ingenuity, as displayed in the continual improvement in machinery, and production of commodities, without parallel, and apparently without limit.* The freedom which, under our government, every man has, to use his capital, his labor, and his talents, in the manner most conducive to his interests, is an inestimable advantage; canals are cut, and railroads constructed, by the voluntary association of persons whose local knowledge enables them to place them in the most desirable situations; and these great advantages cannot exist under less free governments. These circumstances, when taken together, give such a decided superiority to our people, that no injurious rivalry, either in the construction of machinery or the manufacture of commodities, can reasonably be anticipated."

325. But even if it were desirable to prevent the exportation of a certain class of machinery, it appears abundantly evident, that, whilst the exportation of other kinds is allowed, it is impossible to prevent the forbidden kind from being smuggled out; and that, in point of fact, the additional risk had been well calculated by the smuggler.

326. It would appear, also, that there are circumstances which show that the immediate exportation of improved machinery is not quite so certain as has been assumed; and that the powerful principle of self-interest will urge the makers of machinery to push its extension in a different direction. When a great maker of machinery has contrived a new machine for any particular process, or has made some great improvement on those in common use, to whom will he naturally apply for the purpose of selling his new machines? Undoubtedly, in by far the majority of cases, he will communicate the circumstance to his nearest and best customers, those to whom he has immediate and personal access, and whose capability to fulfil any contract is best known to him. He will communicate with them, and offer to take their orders for the new machine; nor will he think of writing to inform foreign customers, so long as he finds the home demand sufficient to employ the whole force of his establishment. Thus, then, the machine-maker is himself interested in giving the first advantage of any new improvement to his own countrymen.

327. In point of fact, the machine-makers in London prefer home orders, and do usually charge an additional price to their foreign customers. Even the amount by which this preference is measured may be found in the evidence before the Committee on the Export of Machinery. It is differently estimated by various engineers, but appears to vary from five up to twenty-five per cent. on the amount of the order. The reasons for this are—1. If the machinery be complicated, one of their best men, well accustomed to the mode of work in the factory, must be sent out to put it up; and there is always a considerable chance of his having offers which will induce him to remain abroad. 2. If the work be of a more simple kind, and can be put up without an English workman, yet for the credit of the house which supplies it, and to prevent accidents which may occur from the want of sufficient instruction in those who use it, the parts are sometimes made stronger, and examined more attentively, than they would be for an English purchaser. Any defect or accident, also, would be attended with more expense to repair, if it occurred abroad, than in England.

328. The class of workmen who make machinery possess much more skill, and are paid much more highly, than that class who merely use it; and, if a free exportation of machinery were allowed, this higher and more valuable class would, undoubtedly, be greatly increased; for, notwithstanding the high price of wages, there is no country in which machinery can at this moment be made, either so well or so cheaply, as in England. We might, therefore, supply the whole world with machinery, at an evident advantage, both to ourselves and our customers. In Manchester, and in the surrounding district, many thousand men are employed wholly in making machinery, which gives employment to many hundred thousands who use it; but the period is not very remote, when the whole number of those who then *made use* of machinery, was not greater than the number of those who now *manufacture* machines. Hence, then, if England should ever become a great exporter of machinery, she would necessarily contain a large class of workmen, to

whom skill would be indispensable, and, consequently, to whom high wages would be paid; and, although her manufacturers might probably be fewer in numbers, yet they would undoubtedly have the advantage of being the first to derive profit from improved machinery. Under such circumstances, any diminution in the demand for machinery would, in the first instance, be felt by a class much better able to meet it, than the class which now suffers upon every check in the consumption of manufactured goods; and the resulting misery would therefore assume a mitigated character.

329. It has been feared, that when other countries have purchased our machines, they will cease to demand new ones. The statement which has been given of the usual progress in the improvement of the machinery employed in any manufacture, and of the average time which elapses before it is superseded by such improvements, is a complete reply to this objection. If our customers did not adopt the new machinery contrived by us as soon as they could procure it, then our manufacturers would extend their establishments, and undersell their rivals in their own markets.

330. It may also be urged, that in each kind of machinery a maximum of perfection may be imagined, beyond which it is impossible to advance; and certainly the last advances are usually the smallest, when compared with those which precede them; but it should be observed, that these advances generally occur when the number of machines in employment is already large; and, consequently, their effects on the power producing are very considerable. But though it should be admitted that any individual species of machinery may arrive, after a long period, at a degree of perfection which would render farther improvement nearly hopeless, yet it is impossible to suppose that this can be the case with all kinds of mechanism. In fact, the limit of improvement is rarely approached, except in extensive branches of national manufactures, and the number of such branches is, even at present, very small.

331. Another argument in favor of the exportation of machinery is, that *it would facilitate the transfer of capital to any more advantageous mode of employment which might present itself.* If the exportation of machinery were permitted, there would doubtless arise a considerable demand; and, supposing any particular branch of our manufactures to cease to produce the average rate of profit, the loss to the capitalist would be much less if a market were opened in which he could sell his machinery to customers more favorably circumstanced for its employment. If, on the other hand, new improvements in machinery should be imagined, the manufacturer would be more readily enabled to carry them into effect, by having the foreign market open to him for the sale of his old machines. The fact that England can, notwithstanding her taxation, and her high rate of wages, undersell other nations, seems to be well established; and it appears to depend on the superior goodness and cheapness of those raw materials of machinery, the metals,—on the excellency of the tools,—and on the admirable arrangements of the domestic economy of our factories.

332. The different degrees of facility with which capital can be transferred from one mode of employment to another, has an important effect on the rate of profits in different trades and in different countries. Supposing every other cause which influences the rate of profit at any period, to act equally on capital employed in different occupations, yet the real rates of profit would soon alter, on account of the different degrees of loss in removing it from one mode of investment to another, or any variation in the action of those causes. This principle will appear more clearly by taking an example. Let two capitalists have embarked £10,000 each, in two trades: A in supplying a district with water, by means of a steam engine and iron pipes; B in manufacturing bobbin-net.

The capital of A will be expended in building a house and erecting a steam engine, which costs say £3000: and laying down iron pipes to supply his customers, costing, say £7000. The greatest part of this latter expense is payment for labor; and if the pipes were to be taken up, the damages to them would render them of little value, except as old metal, whilst the expense of removing them would be considerable. Let us, therefore, suppose, that if A were obliged to give up his trade, he could only realize £4000 by the sale of his stock. Let us suppose that B, by the sale of his bobbin-net factory, and machinery, could realize £8000. Farther, let us suppose the usual rate of interest made on the capital employed by each is the same, say 20 per cent.: then we have

	Capital invested.	Money which would arise from sale of machinery.	Annual rate of profit per cent.	Income.
Water-works - -	£10,000	£4,000	£20	£2,000
Bobbin-net Factory	10,000	8,000	20	2,000

Now, if, from competition, or any other causes, the rate of profit arising from water-works should fall to ten per cent., that circumstances would not cause a transfer of capital from water-works to bobbin-net making; because the reduced income from the water-works, £1000 per annum, would still be greater than that produced by investing £4000, (the whole sum arising from the sale of the materials of the water-works,) in a bobbin-net factory; which sum, at 20 per cent., would only yield £800 per annum. In fact, the rate of profit, arising from the water-works, must be reduced below eight per cent., before it would benefit the proprietor's income to remove his capital into the bobbin-net trade.

333. In any inquiry into the probability of the injury arising to our manufacturers from the competition of foreign countries, particular re-

gard should be had to the facilities of transport, and to the existence in our own country of a mass of capital in roads, canals, machinery, &c., the greater portion of which may fairly be considered as having repaid the expense of its outlay, and also to the cheap rate at which the abundance of our fuel enables us to produce iron, the basis of almost all machinery. It has been justly remarked by M. de Villefosse, in the memoir before alluded to, that "Ce que l'on nomme en France, la *question du prix des fers*, est, a proprement parler, la *question du prix des bois*, et *la question des moyens de communications interieures par les routes, fleuves, rivieres et canaux*."

On referring to page 34 of the present volume, the price of iron in various countries in Europe has been stated; and it appears that, in England, it is produced at the least, and in France at the greatest expense. The length of the roads which cover England and Wales may be stated roughly at twenty thousand miles of turnpike, and one hundred thousand miles of road not turnpike. The internal water communication of England and France, as far as I have been able to collect information on the subject, may be stated as follows:—In France, navigable rivers, 4668 miles in length; navigable canals, 915·5 miles; navigable canal in progress of execution, (1824,) 1388 miles. Total, 6971·5.* But if we reduce these numbers in the proportion of 3·7 to 1, which is the relative area of France as compared with England and Wales, then we shall have the following comparison:

		England.†	Portion of France equal in size to England and Wales.
		Miles.	*Miles.*
Navigable Rivers - - -		1275.5	1261.6
Tidal Navigation‡ - - -		545.9	
Canals, direct -	2023.5		
——— branch -	150.6		
	2174.1	2174.1	247.4
Canals commenced - - -		..	375.1
Total - - - - - - - -		3995.5	1884.1
Population in 1831 - - -		13,894,500	8,608,500

This comparison, between the internal communications of the two countries, is not offered as complete; nor is it a fair view, to contrast the wealthiest portion of one country with the whole of the other: but it is offered with the hope of inducing those who possess more extensive information on the subject, to supply the facts on which a better comparison may be instituted. The information to be added would consist of the number of miles in each country, of sea-coast,—of public roads,—of railroads,—of railroads on which locomotive engines are used.

334. One point of view, in which rapid modes of conveyance increase the power of a country, deserves attention. On the Manchester railroad, for example, above half a million of persons travel annually; and supposing each person to save only one hour in the time of transit, between Manchester and Liverpool, a saving of five hundred thousand hours, or of fifty thousand working days, of ten hours each, is effected. Now this is equivalent to an addition to the actual power of the country of one hundred and sixty-seven men, without increasing the quantity of food consumed; and it should also be remarked, that the time of the class of men thus supplied is far more valuable than that of mere laborers.

ON THE FUTURE PROSPECTS OF MANUFACTURES, AS CONNECTED WITH SCIENCE.

335. In reviewing the various processes which have been offered in the course of the present volume, as illustrations of those general principles which it has been its main object to support and establish, it is impossible not to perceive that the arts and manufactures of the country are intimately connected with the progress of the severer sciences; and that, as we advance in the career of improvement, every step requires, for its success, that this connection should be rendered more intimate.

The applied sciences derive their facts from experiment; but the reasonings, on which their chief utility depends, come more properly within the province of what is called abstract science. It has been shown, that the division of labor is no less applicable to mental productions than to those in which material bodies are concerned; and it follows, that the efforts for the improvement of its manufactures, which any country can make with the greatest probability of success, must arise from the combined exertions of all those most skilled in the theory, as well as in the practice of the art; each laboring in that department for which his natural capacity and acquired habits have rendered him most fit.

336. The profits arising from the successful application to practice of theoretical principles will, in most cases, amply reward, in a pecuniary sense, those by whom they are first employed: yet, even here, what has been stated with respect to *patents* will prove that there is room for considerable amendment in our legislative enactments: but the discovery of the great principles of nature demands a mind almost solely devoted to such investigations; and these, in the present state of science, frequently require costly apparatus, and exact an expense of time quite incompatible with professional avocations. It becomes, therefore, a fit subject for consideration, whether it would not be politic in a state to compensate for some of those privations to which the cultivators of the higher departments of science are exposed;

* This statement is extracted and reduced from one in the Ravinet Dictionnaire Hydrographique, 2 vols. 8vo. Paris, 1824.

† I am indebted to F. Page, Esq of Speen, for that portion of this table which relates to the internal navigation of England: those only who have themselves collected statistical details, can be aware of the time and labor, of which the few lines in the above table are the result.

‡ The tidal navigation includes—the Thames from the mouth of the Medway,—the Severn from the Holmes,—the Trent from Trent Falls in the Humber,—the Mersey from Runcorn Gap.

and the best mode of effecting this compensation is a question which interests both the philosopher and the statesman. Such considerations appear to have had their just influence in other countries, where the pursuit of science is regarded as a profession, and where those who are successful are not shut out from almost every object of honorable ambition to which their fellow-countrymen may aspire. Having, however, already expressed some opinion upon these subjects in another publication,* I shall here content myself with referring to that work.

337. But it is of something beyond neglect, of which the science of England complains: for whilst in our own country, whose advancement in wealth and strength so peculiarly depends upon the aid of the sciences, no encouragement is held out to that which must ever precede their application to the practical purposes of life; whilst abstract science, the prolific parent of the useful arts—the unfailing guide in tracing to their remotest conclusions the natural laws which observations may have detected—is allowed by the state to entail upon its cultivators the sacrifice of all those personal interests which the exercise of the same powers of mind might command in any other pursuit: Englishmen are precluded from accepting those distinctions from the enlightened sovereigns of other countries, by which they might desire to express their respect for British science.†

There was, indeed, in our own country, one single position to which science, when concurring with independent fortune, might aspire, as conferring rank and station; an office deriving, in the estimation of the public, more than half its value from the commanding knowledge of its possessor; and it is extraordinary, that even that solitary dignity—that barony by tenure in the world of British science—the chair of the Royal Society,—should have been coveted for adventitious rank. It is more extraordinary, that a prince, distinguished by the liberal views he has invariably taken of public affairs—and eminent for his patronage of every institution calculated to alleviate those miseries from which, by his rank, he is himself exempted—who is stated by his friends to be the warm admirer of knowledge, and most anxious for its advancement,—should have been so imperfectly informed by those friends, as to have wrested from the head of Science the only civic wreath which could adorn its brow.‡

In the meanwhile the President may learn, through the only medium by which his elevated station admits approach, that those evils which were anticipated from his election have not proved to be imaginary, and that the advantages by some expected to result from it, have not yet become apparent. It may be right also to state, that whilst many of the inconveniences which have been experienced by the President of the Royal Society have resulted from the conduct of his own supporters, those who were compelled to differ from him have subsequently offered no vexatious opposition: they wait in patience, convinced that the force of truth must ultimately work its certain, though silent course; and not doubting that, when His Royal Highness is correctly informed, he will himself be among the first to be influenced by its power.

338. But younger institutions have arisen to supply the deficiencies of the old; and very recently a new combination, differing entirely from the older societies, promises to give additional steadiness to the future march of science. The "*British Association for the Promotion of Science*," which held its first meeting at York, in the year 1831, would have acted as a powerful ally, even if the Royal Society were all that it might be: but in the present state of that body, such an association is almost necessary for the purposes of science. The periodical assemblage of persons, pursuing the same or different branches of knowledge, always produces an excitement which is favorable to the developement of new ideas; whilst the long period of repose which succeeds, is advantageous for the prosecution of the reasonings or the experiments then suggested: and the recurrence of the meeting in the succeeding year will still stimulate the activity of the inquirer, by the hope of being then enabled to produce the successful result of his labors. Another advantage is, that such meetings bring together a much larger number of persons actively engaged in science, or placed in positions in which they can contribute to it, than can ever be found at the ordinary meetings of other societies, even in the most populous capitals; and combined efforts towards any particular object can thus be more easily arranged.

But perhaps the greatest benefit which will accrue to science from these assemblies, is the intercourse which they cannot fail to promote between the different classes of society. The man of science will derive practical information from the great manufacturers; the che-

* Reflections on the Decline of Science in England, and on some of its Causes. 8vo. 1830. Fellowes

† The intentions of a Northern Sovereign, distinguished by his attachment to science, were some time ago defeated by information from his ambassador in London, of the existence of the regulation by which it was understood that the acceptance of such honor by British subjects is forbidden.

‡ The Duke of Sussex was proposed as President of the Royal Society, in opposition to the wish of the Council—in opposition to the public declaration of a body of Fellows, comprising the largest portion of those by whose labors the character of English science had been maintained. The aristocracy of rank and power, aided by such allies as it can always command, set itself in array against the prouder aristocracy of science. Out of about seven hundred members, only two hundred and thirty balloted; and the Duke of Sussex had a majority of EIGHT. Under such circumstances, it was, indeed, extraordinary that his Royal Highness should have condescended to accept the fruits of that doubtful and inauspicious victory. The circumstances preceding and attending this singular contest have been most ably detailed in a pamphlet, entitled, "A Statement of the Circumstances connected with the late Election for the President of the Royal Society. 1831: printed by R. Taylor, Red Lion court, Fleet street." The whole tone of the tract is strikingly contrasted with that of the productions of some of those persons by whom it was his Royal Highness's misfortune to be supported.

mist will be indebted to the same source for substances which exist in such minute quantity as only to become visible in most extensive operations; and persons of wealth and property, resident in each neighborhood visited by these migratory assemblies, will derive greater advantages than either of those classes, from the real instruction they may procure respecting the produce and manufactures of their country, and the enlightened gratification which is ever attendant on the acquisition of knowledge.*

339. Thus, it may be expected that public opinion shall be brought to bear upon the world of science; for by this intercourse light will be thrown upon the characters of men, and the pretender and the charlatan will be driven into merited obscurity. Without the action of public opinion, any administrator, however anxious to countenance the pursuits of science, and however ready to reward by wealth and honors those whom they might think most eminent, would run the risk of acting like the blind man recently couched, who, having no mode of estimating degrees of distance, mistook the nearest and most insignificant for the largest objects in nature: it becomes, therefore, doubly important, that the man of science should mix with the world.

It is highly probable that in the next generation, the class of scientific men in England will spring from a class of persons altogether different from that which has hitherto scantily supplied them. Requiring, for the success of their pursuits, previous education, leisure, and fortune, few are so likely to unite these essentials as the sons of our wealthy manufacturers, who, having been enriched by their own exertions, in a field connected with science, will be ambitious of having their children distinguished in its ranks. It must, however, be admitted, that this desire in the parents would acquire great additional intensity, if worldly honors occasionally followed successful efforts; and that the country would thus gain for science, talents which are frequently rendered useless by the unsuitable situations in which they are placed.

340. The discoveries of Iodine and Brome, two substances hitherto undecompounded, were both amongst the class of manufacturers, one being a maker of saltpetre at Paris, the other a manufacturing chemist at Marseilles: and the inventor of balloons filled with rarified air, was a paper manufacturer near Lyons. The descendants of Mongolfier, the first aerial traveller, still carry on the establishment of their progenitor, and still continue to combine great scientific knowledge with every department of the arts, to which the various branches of the family have applied themselves.

* The advantages likely to arise from such an association have been so clearly stated in the address delivered by the Rev. Mr. Vernon Harcourt, at its first meeting, that I would strongly recommend its perusal by all those who feel interested in the success of English science.—[Vide First Report of the British Association for the Advancement of Science. York, 1832.]

341. Chemical science may, in many instances, be of great importance to the manufacturer, as well as to the merchant. The quantity of Peruvian bark which is imported into Europe is very considerable; but chemistry has recently proved that a large portion of the bark itself is useless. The alkali Quinia, which has been extracted from it, possesses all the properties for which the bark is valuable, and only forty ounces of this substance, when in combination with sulphuric acid, can be extracted from a hundred pounds of the bark. In this instance, then, with every ton of useful matter, thirty-nine tons of rubbish are transported across the Atlantic.

At the present time, the greatest part of the sulphate of quinia used in this country is imported from France, where the low price of the alcohol, by which it is extracted from the bark, renders the process cheap; but it cannot be doubted, that when more settled forms of government shall have given security to capital, and when advancing civilization shall have spread over the states of Southern America, the alkaline medicine will be extracted from the woody fibres, by which its efficacy is almost lost, and that it will be exported in its most condensed form.

342. The aid of chemistry, in extracting and in concentrating substances used for human food, is of great use in distant voyages, where the space occupied by the stores must be economized with the greatest care. Thus, the essential oils supply the voyager with flavor—the concentrated and crystallized acids preserve his health—and alcohol, when sufficiently diluted, supplies the spirit necessary for his daily consumption.

343. When we reflect on the very small number of species of plants, compared with the multitude that are known to exist, which have hitherto been cultivated, and rendered useful to man, and when we apply the same observation to the animal world, and even to the mineral kingdom, the field that natural science opens to our view seems to be indeed unlimited. These productions of nature, numerous and varied as they are, may each, in some future day, become the basis of extensive manufactures, and give life, employment, and wealth, to millions of human beings. But the crude treasures perpetually exposed before our eyes contain within them other and more valuable principles. All these, in their innumerable combinations, which ages of labor and research can never exhaust, may be destined to furnish, in perpetual succession, new sources of our wealth and of our happiness. Science and knowledge are subject, in their extension and increase, to laws quite opposite to those which regulate the material world. Unlike the forces of molecular attraction, which cease at sensible distances, or that of gravity, which decreases rapidly with the increasing distance from the point of its origin, the farther we advance from the origin of our knowledge, the larger it becomes, and the

greater power it bestows upon its cultivators, to add new fields to its dominions. Yet, does this continually and rapidly increasing power, instead of giving us any reason to anticipate the exhaustion of so fertile a field, place us at each advance on some higher eminence, from which the mind contemplates the past, and feels irresistibly convinced, that the whole, already gained, bears a constantly diminishing ratio to that which is contained within the still more rapidly expanding horizon of our knowledge.

But, if the knowledge of the chemical and physical properties of the bodies which surround us, as well as our acquaintance with the less tangible elements, light, electricity, and heat, which mysteriously modify or change their combinations, all concur to convince us of the same fact; we must remember that another and a higher science, itself still more boundless, is also advancing with a giant's stride, and having grasped the mightier masses of the universe, and reduced their wanderings to laws, has given to us, in its own condensed language, expressions, which are to the past as history, to the future as prophecy. It is the same science which is now preparing its fetters for the minutest atoms that nature has created: already it has nearly chained the ethereal fluid, and bound it in one harmonious system all the intricate and splendid phenomena of light. It is the science of *calculation*,—which becomes continually more necessary at each step of our progress, and which must ultimately govern the whole of the applications of science to the arts of life.

But perhaps a doubt may arise in the mind, whilst contemplating the continually increasing field of human knowledge, that the weak arm of man may want the physical force requisite to render that knowledge available. The experience of the past has stamped, with the indelible character of truth, the maxim, that "*Knowledge is power.*" It not merely gives to its votaries control over the mental faculties of their species, but is itself the generator of physical force. The discovery of the expansive power of steam, its condensation, and the doctrine of latent heat, has already added to the population of this small island, millions of hands. But the source of this power is not without limit, and the coal-mines of the world may ultimately be exhausted. Without adverting to the theory, that new formations of that mineral are now depositing under the sea, at the estuaries of some of our larger rivers; without anticipating the application of other fluids requiring a less supply of caloric than water: we may remark that the sea itself offers a perennial source of power hitherto almost unapplied. The tides, twice in each day, raise a vast mass of water, which might be made available for driving machinery. But supposing heat still to remain necessary when the exhausted state of our coal-fields renders it expensive: long before that period arrives, other methods will probably have been invented for producing it. In some districts, there are springs of hot water, which have flowed for centuries unchanged in temperature. In many parts of the island of Ischia, by deepening the sources of the hot springs but a few feet, the water boils: and there can be little doubt that, by boring a short distance, steam of high pressure would issue from the orifice.*

In Iceland, the sources of heat are still more plentiful; and their proximity to large masses of ice seems almost to point out the future destiny of that island. The ice of its glaciers may enable its inhabitants to liquify the gases with the least expenditure of mechanical force: and the heat of its volcanoes may supply the power necessary for their condensation. Thus, in a future age, *power* may become the staple commodity of the Icelanders, and of the inhabitants of other volcanic districts;† and possibly the very process by which they will procure this article of exchange for the luxuries of happier climates may, in some measure, tame the tremendous element which occasionally devastates this province.

344. Perhaps to the sober eye of inductive philosophy, these anticipations of the future may appear too faintly connected with the history of the past. When time shall have revealed the future progress of our race, those laws which are now obscurely indicated will then become distinctly apparent; and it may possibly be found that the dominion of mind over the material world advances with an ever-accelerating force.

Even now, the imprisoned winds which the earliest poet made the Grecian warrior bear for the protection of his fragile bark; or those which, in more modern times, the Lapland wizards sold to the deluded sailors; these, the unreal creations of fancy or of fraud, called, at the command of science, from their shadowy existence, obey a holier spell: and the unruly masters of the poet and the seer become the obedient slaves of civilized man.

Nor has the wild imagination of the satirist been quite unrivalled by the realities of after years: as if in mockery of the College of Laputa, light almost solar has been extracted from the refuse of fish; fire has been sifted by the lamp of Davy; and machinery has been taught arithmetic instead of poetry.

345. In whatever light we examine the triumphs and achievements of our species over the creation submitted to its power, we explore new sources of wonder. But if science has called into real existence the visions of the poet —if the accumulating knowledge of ages has blunted the sharpest, and distanced the loftiest

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* In 1828, the author of these pages visited Ischia, with a Committee of the Royal Academy of Naples, deputed to examine the temperature and chemical constitution of the springs in that island. During the first few days, several springs, which had been represented in the instructions as under the boiling temperature, were found, on deepening the excavations, to rise to the boiling point.

† See § 268, p. 62.

of the shafts of the satirist, the philosopher has conferred on the moralist an obligation of surpassing weight.

In unveiling to him the living miracles which teem in rich exuberance around the minutest atom, as well as throughout the largest masses of ever-active matter, he has placed before him resistless evidence of immeasurable design. Surrounded by every form of animate and inanimate existence, the sun of science has yet penetrated but through the outer fold of Nature's majestic robe; but if the philosopher were required to separate, from amongst those countless evidences of creative power, one being, the masterpiece of its skill; and from that being to select one gift, the choicest of all the attributes of life; turning within his own breast, and conscious of those powers which have subjugated to his race the external world, and of those higher powers by which he has subjugated to himself that creative faculty which aids his faltering conceptions of a deity, —the humble worshipper at the altar of truth would pronounce that being,—man: that endowment,—human reason.

But however large the interval that separates the lowest from the highest of those sentient beings which inhabit our planet, all the results of observation, enlightened by all the reasonings of the philosopher, combine to render it probable that, in the vast extent of creation, the proudest attribute of our race is but, perchance, the lowest step in the gradation of intellectual existence. For, since every portion of our own material globe, and every animated being it supports, afford, on more scrutinizing inquiry, more perfect evidence of design, it would indeed be most unphilosophical to believe that those sister spheres, glowing with light and heat, radiant from the same central scource—and that the members of those kindred systems, almost lost in the remoteness of space, and perceptible only from the countless multitude of their congregated globes—should each be no more than a floating chaos of unformed matter; or, being all the work of the same Almighty Architect, that no living eye should be gladdened by their forms of beauty, that no intellectual being should expand its faculties in deciphering their laws.

FINIS.